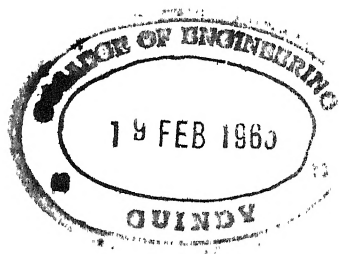


INDEX  
TO  
TRANSACTIONS  
OF THE  
AMERICAN INSTITUTE  
OF  
ELECTRICAL ENGINEERS  
1901 TO 1910 INCLUSIVE



---

VOLUME 2

---

PUBLISHED BY THE  
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS  
33 WEST THIRTY-NINTH STREET  
NEW YORK, N. Y., U. S. A.

1913

Copyright, 1913  
by the  
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

## INTRODUCTION

---

This index of the TRANSACTIONS consists of two separate parts, each intended for a distinct purpose.

First. There is an index of papers in which they are classified in natural groups and arranged chronologically in each group.

Second. There is an index of specific data and information arranged alphabetically.

The index of papers is intended for searchers desiring to locate papers on a given subject, and to aid in this search the papers have been characterized. These characterizations are not intended to be abstracts of the papers, but rather to give the scope and nature of their contents. The titles of many papers are misleading, and it is hoped thus to call the searcher's attention to the real nature of the contents, thus saving him much time in looking up useless references.

The index of specific data and information is intended for searchers desiring to make a complete study of the subject as presented in the TRANSACTIONS. There is a great mass of valuable information hidden in discussions which have no very direct connection with the subject of the paper. This data can be found only by reference to such a topical index.

Methods of classification of engineering information are as numerous as the people who have studied the subject. A logically arranged classification for this index seemed impossible. Accordingly all information was grouped into natural classes and very complete cross indexing was provided. The searcher will thus be lead to the desired information whatever may be his ideas of a proper arrangement.

The classification of the papers was determined by sorting them for the entire period covered by the index. Any group containing a large number of papers was subdivided. All papers were arranged chronologically to enable the searcher to pass over the early papers that might be too old for his use.

Naturally, many papers, especially when considered together with their discussions, fell into a number of different groups. In all such cases they were put into as many places as it was thought they might possibly belong. If there was any doubt one way or the other, a paper was always put in.

There is no harm in having a paper under a heading where someone thinks it should not be, so long as it is also under the heading where that person thinks it ought to be. For instance, many high-tension systems ordinarily considered transmission lines, are to all intents and purposes distribution systems. In the future they will undoubtedly be considered

such as we now consider as distribution systems those which some years ago we looked upon as transmission lines. Accordingly, papers dealing with high-tension distribution systems are listed both under transmission and distribution.

The topical index is not a classified index in the ordinary sense. However, all of the information is properly grouped in an alphabetical manner. The conditions it was intended to carry out were as follows:

1. To index all useful specific data and information contained in the TRANSACTIONS.

2. To arrange the index items in such a manner that anybody could find them with a minimum of trouble.

In the attempt to meet these conditions the following general rules were observed:

1. All subjects are indexed under the noun, and where an adjective is practically inseparably associated with a noun by usage, it has been incorporated with it by a hyphen.

2. All references to a given subject are listed in the same place, so that having found one reference the searcher can rest assured that he has found all.

3. Apparatus and phenomena known by several names are grouped under one name and the other names inserted in the index with cross references. For instance, inductance coils, reactance coils, reactive coils, choke coils, reactors will all be found in the index with cross references to Reactors.

4. Apparatus and phenomena common to two or more subjects are grouped by themselves and cross references inserted under the related subjects. Thus, commutation is indexed by itself with cross references under generators, d. c.; motors, a. c.; motors, d. c.

5. Apparatus and phenomena of sufficient importance in themselves are indexed alone with cross references under the main heads of which they form a sub-division. Thus, catenary construction is indexed under catenary construction with cross reference under distribution, railway.

6. All properties of materials and apparatus are indexed under the name of the material or apparatus, except where the references are to the characteristics of the properties themselves. Therefore, a searcher will find under the name of a material all the properties of that material given in the TRANSACTIONS.

7. No distinction is made between singular and plural in arrangement of the items.

An attempt has thus been made to make it impossible for a searcher not to find all the information which is contained in the TRANSACTIONS. Actual use of the index can alone determine the success or failure of this undertaking. But, however unsuccessful in this particular, it is believed that this index will greatly increase the value of the TRANSACTIONS.



# 1. EDUCATION

## PRESIDENTIAL ADDRESS

Charles P. Steinmetz

Vol. xix—1902, pp. 1145-1150

Description of the shortcomings in present methods of teaching engineering in colleges. Outline of an ideal course in electrical engineering.

*Discussion*, incorporated with that of paper by E. B. Raymond on "A Proposed Reform in Technical Training."

## CONCERNING UNIFORMITY IN ELECTRICAL ENGINEERING COURSES IN THE UNITED STATES

Samuel Sheldon

Vol. xix—1902, pp. 1151-1154

Purpose of engineering schools. Statistics bearing on the uniformity of courses in different colleges, and brief discussion of the kind of training required by engineers.

*Discussion*, incorporated with that of paper by E. B. Raymond on "A Proposed Reform in Technical Training."

## ELECTRICAL ENGINEERING COURSES AT COLLEGE AND THE EDUCATION OF THE ELECTRICAL ENGINEER

William Esty

Vol. xix—1902, pp. 1155-1164

General outline of ideal method of instructing engineering students; kind of studies, laboratory method; seminary method; theses, etc.

*Discussion*, incorporated with that of paper by E. B. Raymond on "A Proposed Reform in Technical Training."

## THE EDUCATION OF THE ELECTRICAL ENGINEER

Harold W. Buck

Vol. xix—1902, pp. 1165-1168

General outline of a course of training for electrical engineers, beginning with preparatory school, continuing through college and ending with an apprenticeship course.

*Discussion*, incorporated with that of paper by E. B. Raymond on "A Proposed Reform in Technical Training."

## A PROPOSED REFORM IN TECHNICAL TRAINING

Edward B. Raymond

Vol. xix—1902, pp. 1169-1173

Plan advocating early entry into studies along a given line, and urging specialization throughout entire educational period.

*Discussion* (including that of Samuel Sheldon on "Concerning Uniformity on Electrical Engineering Courses in the United States," Presidential Address, by Charles P. Steinmetz, paper by William Esty on "Electrical Engineering Courses at College and the Education of the Electrical Engineer"; and paper by Harold W. Buck on "The Education of the Electrical Engineer"), pp. 1175-1210, by Messrs. Chas. P. Steinmetz, F. A. C. Perrine, E. B. Raymond, Morgan Brooks, William Stanley,

W. E. Goldsborough, C. A. Adams, Jr., C. P. Matthews, Geo. F. Sever, Chas. E. Skinner, and R. W. Pope. General remarks on methods and ideals of electrical engineering education.

**THE TEACHING OF PHYSICS TO ENGINEERING STUDENTS**

W. S. Franklin

Vol. xxii—1903, pp. 561-566

Discussion of certain common faults in teaching methods, followed by a general outline of the author's method.

*Discussion*, p. 567, by Messrs. W. E. Goldsborough and A. S. Langsdorf.

**THE PROBLEMS THAT ARE FACING THE ELECTRICAL ENGINEER OF TO-DAY  
AND THE QUALITIES OF MIND AND CHARACTER WHICH ARE  
NEEDED TO MEET THEM**

J. G. White

Vol. xxii—1903, pp. 569-578

Outline of the scope and character of training required by engineers. Qualifications for successful engineer.

*Discussion*, incorporated with that of paper by L. A. Osborne on "Proper Qualifications of Electrical Engineering School Graduates, from the Manufacturer's Standpoint."

**THE PROPER QUALIFICATIONS OF ELECTRICAL ENGINEERING SCHOOL GRADUATES  
FROM THE TELEPHONE ENGINEERS STANDPOINT**

Bancroft Gherardi, Jr.

Vol. xxii—1903, pp. 579-586

Outline of the functions of a technical education and criticisms of technical graduates.

*Discussion*, incorporated with that of paper by L. A. Osborne on "Proper Qualifications of Electrical Engineering School Graduates, from the Manufacturer's Standpoint."

**PROPER QUALIFICATIONS OF ELECTRICAL ENGINEERING SCHOOL GRADUATES,  
FROM THE MANUFACTURER'S STANDPOINT**

L. A. Osborne

Vol. xxii—1903, pp. 587-591

Suggestions for improvement of technical education of engineers for manufacturing work.

*Discussion* (including that of paper by J. G. White on "The Problems that are Facing the Electrical Engineer of To-day and the Qualities of Mind and Character which are Needed to Meet them"; and paper by Bancroft Gherardi, Jr., on "The Proper Qualifications of Electrical Engineering School Graduates from the Telephone Engineer's Standpoint"), pp. 592-598, by Messrs. W. E. Goldsborough, Prof. Jacoby, A. F. Ganz, F. C. Caldwell, Hugo Diemer, Prof. Allen, Prof. Waldo, J. G. White, H. S. Carhart and D. B. Rushmore.

Engineering education from a teacher's standpoint.

**THE TYPICAL COLLEGE COURSES DEALING WITH THE PROFESSIONAL AND  
THEORETICAL PHASES OF ELECTRICAL ENGINEERING**

Dugald C. Jackson

Vol. xxii—1903, pp. 599-607

Characterization of students entering college and outline of studies requisite for their training as electrical engineers. Classification of typical electrical engineering courses.

No discussion.

**ENGINEERING ENGLISH**

T. J. Johnston

Vol. xxii—1903, pp. 609-614

Examples of poor engineering English and a plea for adequate instruction in English.

No discussion.

**TRAINING AN ARTIST IN THE FORCES OF NATURE**

E. H. Mullin

Vol. xxii—1903, pp. 615-622

Faults in modern educational methods. Discussion of education as an art and as a science.

No discussion.

**THE ATTITUDE OF THE TECHNICAL SCHOOL TOWARD THE PROFESSION  
OF ELECTRICAL ENGINEERING**

Henry H. Norris

Vol. xxvi—1907, pp. 1429-1439

Outline of the purpose of technical education, followed by brief résumé of the history of technical schools in the United States, with special reference to Sibley College and its early development. Short description of present curriculum at Sibley College and method of rating students searching employment. Table of present occupation of Sibley graduates.

*Discussion*, incorporated with paper by V. Karapetoff on "On the Concentric Method of Teaching Electrical Engineering."

**ON THE CONCENTRIC METHOD OF TEACHING ELECTRICAL ENGINEERING**

V. Karapetoff

Vol. xxvi—1907, pp. 1441-1456

Description of a new method of education that begins by establishing a general view of the scope and character of the career, and then works gradually outward, taking up the auxiliary studies as the student learns to appreciate their use and importance. The general exposition of the method is followed by a suggested schedule of subjects for a complete electrical engineering course.

*Discussion* (including that of paper by Henry H. Norris on "The Attitude of the Technical School Toward the Profession of Electrical Engineering"), pp. 1457-1468, by Messrs. V. Karapetoff, F. D. Crocker, Gano Dunn, William Esty, G. W. Patterson, Lester W. Gill, L. D. Nordstrum, Charles F. Scott and J. J. Carty.

Criticisms of the concentric method of education. General remarks on methods used in various important engineering schools. Motion carried to appoint Educational Committee.

## I. EDUCATION

## THE BEST ENGINEERING EDUCATION

Charles F. Scott

Vol. xxvii—1908, pp. 67-78

General scope and purpose of engineering education; followed by a digest of all the educational papers presented before the Institute since 1892.

*Discussion*, incorporated with Chas. P. Steinmetz's paper on "Electrical Engineering Education."

## ELECTRICAL ENGINEERING EDUCATION

Chas. P. Steinmetz

Vol. xxvii—1908, pp. 79-85

Criticism of the American system of education, with special reference to the compensation of teachers, etc.

*Discussion* (included with the paper by Chas. F. Scott on "The Best Engineering Education"), pp. 86-135, by Messrs. Chas. F. Scott, Chas. P. Steinmetz, L. A. Osborne, H. E. Clifford, F. B. Crocker, H. W. Buck, W. S. Franklin, L. B. Stillwell, Albert F. Ganz, J. G. White, W. E. S. Temple, Louis A. Ferguson, Samuel Sheldon, P. H. Thomas, W. L. Robb, C. O. Mailloux, A. E. Kennelly, H. P. Coho, A. S. McAllister, O. J. Ferguson, H. W. Blake, and Dugald C. Jackson.

Comprehensive discussion on the scope and character of engineering education, pointing out defects and suggesting reforms.

## THE NEW METHOD OF TRAINING ENGINEERS

Magnus W. Alexander

Vol. xxvii—1908, pp. 1459-1471

Experience with the General Electric apprenticeship course at Lynn. Plan outlined for co-operative engineering course between colleges and factories.

*Discussion*, incorporated with paper by B. A. Behrend on "The Relation of the Manufacturing Company to the Technical Graduate."

## RELATION OF THE MANUFACTURING COMPANY TO THE TECHNICAL GRADUATE

David B. Rushmore

Vol. xxvii—1908, pp. 1473-1476

No discussion.

## THE RELATION OF THE MANUFACTURING COMPANY TO THE TECHNICAL GRADUATE

B. A. Behrend

Vol. xxvii—1908, pp. 1477-1479

*Discussion* (including that of paper by Magnus W. Alexander on "The New Method of Training Engineers," and paper by David B. Rushmore on "Relation of the Manufacturing Company to the Technical Graduate"), pp. 1480-1497, by Messrs. B. A. Behrend, J. P. Jackson, Elihu Thomson, Percy H. Thomas, Morgan Brooks, Henry H. Norris, Charles P. Steinmetz, Dugald C. Jackson, C. A. Adams, A. F. Ganz, Charles F. Scott, Gano Dunn and M. W. Alexander.

General discussion of the advantages and disadvantages of co-operative system of education from different points of view.

## FUNDAMENTAL PRINCIPLES OF INDUSTRIAL EDUCATION

Herman Schneider

Vol. xxviii—1909, pp. 269-278

Description of a system of education involving co-operation between the industrial companies and public schools, the pupils dividing their time between the factory and the school. Results from systems in use.

*Discussion*, pp. 279-311, by Messrs. Harry Barker, Arthur D. Dean, C. E. Downton, Charles P. Steinmetz, W. S. Franklin, John Price Jackson, Otis Allen Kenyon, Dugald C. Jackson, A. R. Dennington, Herman Schneider, Charles S. Howe, V. Karapetoff, G. M. Basford, Jackson C. Humphries, Ralph W. Pope, Sidney W. Ashe, Franklin Phillips and Willard S. Atkinson.

Discussion of general and industrial education, with special reference to the co-operative system, night schools, apprenticeship courses and lecture courses for employees.

## THE TRAINING OF NON-TECHNICAL MEN

C. R. Dooley

Vol. xxviii—1909, pp. 1095-1101

Description of the apprenticeship and night school systems used in training non-technical men employed by the Westinghouse Companies at East Pittsburgh.

*Discussion*, incorporated with that of Dr. Charles P. Steinmetz's paper on "The Value of Classics in Engineering Education."

## THE VALUE OF CLASSICS IN ENGINEERING EDUCATION

Charles P. Steinmetz

Vol. xxviii—1909, pp. 1103-1106

Criticism of modern engineering education.

*Discussion*, pp. 1107-1131, including discussion of paper by Mr. C. R. Dooley on "The Training of Non-Technical Men," by Messrs. Charles P. Steinmetz, Frederick P. Fish, Comfort A. Adams, Farley Osgood, M. G. Lloyd, John C. Parker, David B. Rushmore, Clayton H. Sharp, James G. White, C. R. Dooley, George F. Sever, George H. Gibson, A. E. Kennelly, H. W. Fisher, J. Dalemont and Ralph D. Mershon.

General discussion of the character and scope of training required by electrical engineers.

## EDUCATION FOR LEADERSHIP IN ELECTRICAL ENGINEERING

Samuel Sheldon

Vol. xxix—1910, pp. 649-662

Statistical study of the importance of electrical engineering and the electrical engineer, followed by general suggestions for the modification of existing college practices, with reference to increasing the chances of engineering graduates becoming leaders.

*Discussion*, pp. 663-674, by Messrs. Charles S. Howe, Abraham Flexner, J. W. Lieb, Jr., A. E. Kennelly, William McClellan, L. B. Stillwell, William J. Berry, A. S. Langsdorf and Samuel Sheldon.

General remarks on electrical engineering education.

## 2. GENERAL THEORY

### THEORETICAL INVESTIGATION OF SOME OSCILLATIONS OF EXTREMELY HIGH POTENTIAL IN ALTERNATING HIGH-POTENTIAL TRANSMISSIONS

Charles Proteus Steinmetz

Vol. xviii—1901, pp. 383-405

Mathematical investigation of the effect of the exponential term in the general equation for alternating-current circuits, followed by numerical examples showing the nature of disturbances due to opening a short-circuit on the line and to connecting the line to a source of alternating-current energy.

*Discussion*, incorporated with that of paper by E. W. Rice, Jr., on "The Control of High-Voltage Systems of Large Power."

### A DISCUSSION OF SOME POINTS IN ALTERNATING-CURRENT THEORY

W. S. Franklin

Vol. xxi—1903, pp. 589-501

Discussion of ideas and conceptions with reference to presentation of theory of alternating current. Criticisms of Dr. Steinmetz's methods—Polar diagram vs. crank diagram, necessity of choosing signs in circuit problems, topographical vs. vector methods, physical basis of transformer and induction motor equations, vector representation of power.

No discussion.

### THE EFFECT OF IRON IN DISTORTING ALTERNATING CURRENT WAVE FORM

Frederick Bedell and Elbert B. Tuttle

Vol. xxv—1906, pp. 671-691

Theoretical investigation of the relation between the third harmonic introduced by iron into the exciting current and the hysteresis loop. Also, an exposition of the relation between the area of the hysteresis loop and the angle of hysteresis advance.

*Discussion*, pp. 692-714, by Messrs. Chas. P. Steinmetz, Philip Torchio, W. S. Franklin, Frederick Bedell, Harold Pender, A. Henry Pikler, S. P. Grace, H. B. Tuttle, S. N. Kintner and A. W. Copley.

Full discussion of wave distortion due to iron, showing that other harmonics than the third modify Professor Bedell's conclusions. References to early work of Huguët, Froelich, Kennelly, Gerosa, Finzi, Eickemeyer and Steinmetz. Effect of wave distortion with different polyphase transformer connections. Derivation of the parabolic law of magnetic induction. Oscillograms of induced e.m.f. showing effect of primary impedance on wave form in core loss tests and in transformers.

### THE PROPERTIES OF ELECTRONS

#### PRESIDENT'S ADDRESS

Samuel Sheldon

Vol. xxvi—1907, pp. 937-968

Conception of electrons and brief exposition of their properties. Application of electronic theory to the explanation of the fundamental principles of electrophysics—conduction of electricity in gases, vapors and

solids; contact, thermal and electromagnetic generation of e. m. f.; dielectric phenomena; radiation, and luminescence.

No discussion.

#### THE GENERAL EQUATIONS OF THE ELECTRIC CIRCUIT

Charles P. Steinmetz

Vol. xxvii—1908, pp. 1231-1305

Mathematical development and physical interpretation of general equations for the electric circuit—covering standing waves, free oscillations and traveling waves in simple and complex circuits. Numerical examples of overhead and underground power transmission circuits, and telephone, telegraph and submarine cable circuits.

*Discussion*, pp. 1306-1307, by Messrs. Frederick Bedell, Dugald C. Jackson, H. L. Wallau; Charles P. Steinmetz and W. S. Franklin.

General remarks on Steinmetz's equations. Brief exposition of Heaviside's method of explaining electric wave motion.

#### AN IMPERFECTION IN THE USUAL STATEMENT OF THE FUNDAMENTAL LAW OF ELECTROMAGNETIC INDUCTION

Carl Hering

Vol. xxvii—1908, pp. 1341-1351

Description and discussion of an experiment that tends to show that present methods of teaching do not give a clear conception of the fundamental law of electromagnetic induction.

*Discussion*, pp. 1352-1371, by Messrs. Charles P. Steinmetz, A. E. Kennelly, Elihu Thomson, W. S. Franklin, Percy H. Thomas, W. P. Graham, George T. Hanchett, George A. Campbell, Tracy D. Waring and Carl Hering.

General remarks on the laws of electromagnetic induction and criticisms of the author's experiment.

#### GRAPHICAL TREATMENT OF THE ROTATING FIELD

R. E. Hellmund

Vol. xxvii—1908, pp. 1373-1394

Development of a graphical method of investigating a rotating field and examples of its application.

*Discussion*, p. 1395, by Messrs. Comfort A. Adams and R. E. Hellmund.

#### A TRIGONOMETRIC METHOD FOR THE SOLUTION OF ALTERNATING-CURRENT PROBLEMS

Harold Pender

Vol. xxvii—1908 pp. 1397-1424

Development of a short method for solving alternating-current problems with examples of its application to single-phase and three-phase transmission lines, transformers and induction motors. Tables of reactance, capacity, resistance and drop factors for use in such calculations.

*Discussion*, pp. 1424-1427, by Messrs. Comfort A. Adams, W. A. Del Mar and L. W. Rosenthal.

Magnitude of errors involved by this method when applied to transmission line calculations.

## EVEN HARMONICS IN ALTERNATING-CURRENT CIRCUITS

John B. Taylor

Vol. xxviii—1909, pp. 725-732

Description of conditions under which even harmonics may be produced in commercial circuits, with special reference to the effect of stray direct current on the performance of stationary transformers. Tests and oscillograms of transformer exciting current with stray direct current in the windings.

*Discussion*, pp. 733-736, by Messrs. Frederick Bedell, V. Karapetoff, Charles F. Scott, Charles P. Steinmetz and John B. Taylor.

Production of even harmonics in alternators and effect of direct-current in the windings of a transformer upon the losses.

## VECTOR POWER IN ALTERNATING-CURRENT CIRCUITS

A. E. Kennelly

Vol. xxix—1910, pp. 1233-1267

Analytical study of vector quantities combating the use of wattless power and wattless current, and advocating the standardization of the counter-clockwise rotation of vectors.

*Discussion*, pp. 1268-1280, by Messrs. C. P. Steinmetz, Gano Dunn, William W. Crawford, John B. Taylor, L. T. Robinson, F. Creedy and A. E. Kennelly.

Polar diagram vs. the crank diagram for vector representation of alternating quantities. Representation of vector power by Mobius & Grassman system of point-analysis.



### 3. MEASUREMENT AND INSTRUMENTS

#### A. UNITS, STANDARDS AND LABORATORIES

##### A NOTE ON AN ACETYLENE-IN-OXYGEN FLAME

Clayton H. Sharp

Vol. xix—1902, pp. 51-54

Description of an acetylene flame burner which might be used as a standard of intensity. Spectrophotometric curve of acetylene and other flames.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

##### THE PRESENT STATUS OF THE QUESTION OF A STANDARD OF LIGHT

Clayton H. Sharp

Vol. xix—1902, pp. 55-57

Brief reference to some of the shortcomings of the present standards of luminous intensity. Advantages of acetylene flame as standard.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

##### MAGNETIC UNITS AND OTHER SUBJECTS THAT MIGHT OCCUPY ATTENTION AT THE NEXT INTERNATIONAL ELECTRICAL CONGRESS

A. E. Kennelly

Vol. xxii—1903, pp. 529-536

Discussion of the disadvantages of the c.g.s. system. Names for all the c.g.s. electromagnetic and electrostatic units suggested for adoption by the International Electrical Congress.

*Discussion*, pp. 537-538, by Messrs. Carl Hering, W. E. Goldsborough and J. P. Jackson.

##### THE LEGALIZED STANDARD OF ELECTROMOTIVE FORCE

Henry S. Carhart

Vol. xxii—1903, pp. 521-523

Legally determined values of e.m.f. of the Clark standard cell. Ratio between the Clark and Weston cells. Reasons for recommending the adoption of the Weston cell as standard.

*Discussion*, pp. 524-527, by Messrs. C. H. Sharp, Carl Hering and W. E. Goldsborough.

Importance of standard cell and potentiometer in practical work. Motion passed to refer specifications for standard cell to Board of Directors.

##### THE NATIONAL BUREAU OF STANDARDS

S. W. Stratton and E. B. Rosa

Vol. xxiv—1905, 999-1050

Description of the Bureau of Standards, its origin, functions, organization, equipment and work. Also a description of the laboratory at the Louisiana Purchase Exposition.

*Discussion*, incorporated with that of paper by Clayton H. Sharp on "A Testing Laboratory in Practical Operation."

## 3. MEASUREMENTS AND INSTRUMENTS

## A TESTING LABORATORY IN PRACTICAL OPERATION

Clayton H. Sharp

Vol. xxiv—1905, pp. 1051-1060

Discussion of the work done by the Electrical Testing Laboratories—its nature and scope. Classification of the orders and the clients.

*Discussion* (including that of paper by S. W. Stratton and E. B. Rosa on "The National Bureau of Standards"), pp. 1061-1065, by Messrs. F. B. Crocker, W. E. Goldsborough, C. O. Mailloux, George F. Sever, C. A. Doremus, William McClellan, S. W. Stratton, John W. Lieb, Jr., and E. B. Rosa.

General remarks on the scope and importance of standardization laboratories. Desirability of international standardization.

## PRIMARY STANDARD OF LIGHT

Charles P. Steinmetz

Vol. xxvii—1908, pp. 1319-1324

Criticism of primary standard based on energy of radiation, recommending standard composed of three component colors of definite wave lengths.

*Discussion*, pp. 1325-1339, by Messrs. A. E. Kennelly, Edwin P. Hyde, W. S. Franklin, Carl Hering, Clayton H. Sharp, C. A. Perkins, John B. Taylor, E. B. Rosa, H. S. Carhart and Charles P. Steinmetz.

General remarks on Steinmetz's proposed standard. Motion carried to refer question of establishing standard to the Bureau of Standards.

## B. ELECTRICAL MEASUREMENTS AND INSTRUMENTS

## THE TRANSFORMER FOR MEASURING LARGE DIRECT CURRENTS

Harris J. Ryan

Vol. xviii—1901, pp. 169-183

Description of the theory of operation, the design and construction of the transformer. Account of tests demonstrating the degree of accuracy under various conditions, such as occur in testing switchboard instruments in place.

*Discussion*, pp. 184-190, by Messrs. Geo. T. Hanchett, Gano S. Dunn, Samuel Sheldon, A. E. Kennelly, C. O. Mailloux and Townsend Wolcott.

Criticism of the method and answers thereto.

## SYNCHRONISM AND FREQUENCY INDICATION

Paul M. Lincoln

Vol. xviii—1901, pp. 255-270

Description of construction and theory of operation of the Lincoln synchroscope and the Lincoln frequency indicator.

*Discussion*, incorporated with that of paper by William Hand Browne, Jr., on "Power-Factor Indicators."

## SOME FUNDAMENTALS OF ELECTRIC METERS

Caryl D. Haskins

Vol. xviii—1901, pp. 271-276

Discussion of the relations between torque, friction and permanency under various surrounding conditions.

*Discussion*, incorporated with that of paper by William Hand Browne, Jr., on "Power-Factor Indicators."

## METERING OF ELECTRICAL ENERGY

Harry P. Davis

Vol. xviii—1901, pp. 277-285

Requirements of a good energy meter and choice of meter rating for different kinds of load based on extensive experience.

*Discussion*, incorporated with that of paper by William Hand Browne, Jr., on "Power-Factor Indicators."

## POWER-FACTOR INDICATORS

William Hand Brown, Jr.

Vol. xviii—1901, pp. 287-312

General discussion of power-factor regulation and methods of measuring power-factor. Description of numerous types and forms of power-factor meters, phase-meters and wattless power meters, and wattless current meters, with short description of the theory of each general type.

*Discussion* (including that of paper by Paul M. Lincoln on "Synchronism and Frequency Indication"; paper by Caryl D. Haskins on "Some Fundamentals of Electric Meters"; paper by Harry P. Davis on "Metering of Electrical Energy"), pp. 313-338, by Messrs. W. S. Barstow, Chas. P. Steinmetz, H. W. Buck, Gano S. Dunn, Ralph D. Mershon, C. F. Scott, Carl Hering, C. O. Mailloux, F. S. Holmes, E. A. Sperry, Henri Boy De La Tour, Henry W. Fisher, H. G. Stott, Chas. Janisch and C. D. Haskins.

Relative merits and comparative performance of direct-current and induction motors. Desirability of charging for apparent and quadrature power. Two-rate meter for peak load differentiation.

LIQUID POTENTIOMETER; DETERMINING ELECTROLYTIC RESISTANCES  
WITH DIRECT-CURRENT INSTRUMENTS

Carl Hering

Vol. xix—1902, pp. 317-323

Description of the instrument and methods of using it.

*Discussion*, incorporated with that of paper by W. R. Whitney on "Colloids."

## THE ELECTROSTATIC WATTMETER IN COMMERCIAL MEASUREMENTS

Miles Walker

Vol. xix—1902, pp. 1035-1045

Discussion of the advantages and disadvantages of the Electrometer. Simple formulas for calculating the torque on the vanes of an electrometer under various practical conditions. Description of a bifilar suspension electrometer.

*Discussion*, incorporated with that of paper by Charles Edward Skinner on "Energy Loss in Commercial Insulating Materials When Subjected to High-potential Strains."

## A NEW CURVE TRACING INSTRUMENT

Robt. B. Owens

Vol. xix—1902, pp. 1123-1129

Description of the instrument and directions for checking current and

e. m. f. waves, and for measuring angular velocity variations in one revolution.

*Discussion*, p. 1130, by F. A. C. Perrine and C. P. Steinmetz.

#### THE CATHODE RAY ALTERNATING-CURRENT WAVE INDICATOR

Harris J. Ryan

Vol. xxii—1903, pp. 539-548

Description of the construction and mode of operation of the cathode tube wave tracer.

*Discussion*, pp. 549-552, by Messrs. G. S. Dunn, P. H. Thomas, Harris J. Ryan, A. F. Ganz, William J. Hammer, C. H. Sharp, H. W. Fisher, A. S. Langsdorf and W. E. Goldsborough

#### A GRAPHIC RECORDING AMMETER

A. H. Armstrong

Vol. xxii—1903, pp. 689-694

Description of the construction and operation of the Armstrong recording instruments for railway testing.

No discussion.

#### SOME NOTES ON POLYPHASE METERING

J. D. Nies

Vol. xxiv—1905, pp. 165-180

Brief outline of nature and magnitude of errors introduced by presence of shunt and series instrument transformers. Relative merits of single-meter, two-meter and three-meter and polyphase meter methods for measuring energy in three-phase circuits.

*Discussion*, incorporated with paper by W. J. Mowbray on "Maintenance of Meters."

#### NOTES ON THE USE OF INSTRUMENTS ON SWITCHBOARDS

F. P. Cox

Vol. xxiv—1905, pp. 181-184

Brief mention of some of the factors which enter into the choice of watt-hour meter rating for a given service, and reference to some of the errors that can be avoided by proper selection and installation of watt-hour meters.

*Discussion*, incorporated with paper by W. J. Mowbray on "Maintenance of Meters."

#### THE OSCILLOGRAPH AND ITS USES

Lewis T. Robinson

Vol. xxiv—1905, pp. 185-214

Description of various methods and apparatus for measuring wave form—Joubert point-by-point method, Elihu Thomson continuous method, Rosa curve tracer, General Electric wave meter, Hospitalier ondograph, Blondel & Duddell oscillographs. Bibliography on subject of wave-form measurement.

*Discussion*, incorporated with paper by W. J. Mowbray on "Maintenance of Meters."

## MAINTENANCE OF METERS

W. J. Mowbray

Vol. xxiv—1905, pp. 215-218

General description of a rotating standard watt-hour meter with plurality of current coils. General remarks on methods of increasing permanence of calibration.

*Discussion* (including that of paper by J. D. Nies on "Some Notes on Polyphase Metering"; paper by F. P. Cox on "Notes on the Use of Instruments on Switchboards," and paper by Lewis T. Robinson on "The Oscillograph and Its Uses"), pp. 219-245, by Messrs. J. W. Lieb, Jr., Caryl D. Haskins, Edward B. Rosa, Clayton H. Sharp, A. R. Everest, W. H. Pratt, G. C. Van Buren, A. H. Ackerman, J. F. Stevens, William McClellan, Charles Hewitt, William Bradshaw, Stephen Q. Hayes, C. W. Hutton, J. W. Swaren, R. F. Monges, C. L. Cory and F. E. Smith.

General remarks on the choice, installation and maintenance of indicating and integrating switchboard instruments. Tests on permanence of calibration of very large number of watt-hour meters giving the limits of accuracy.

## METHODS OF MEASUREMENT OF HIGH ELECTRICAL PRESSURES

S. M. Kintner

Vol. xxiv—1905, pp. 421-444

Brief résumé of the various methods of measuring very high e. m. f.'s., pointing out the principal limitations of each. Experimental study of the spark gap for e. m. f. measurement, showing the effect of various current limiting devices, grounding and shielding. Description and discussion of the advantages of an oil-immersed electrostatic voltmeter for e. m. f.'s. up to 100,000 volts.

*Discussion*, pp. 445-451, by Messrs. Charles P. Steinmetz, Samuel Sheldon, C. O. Mailloux, H. G. Stott, H. W. Fisher, E. F. Northrup, Charles A. Perkins and S. M. Kintner.

Advantages of potential transformers in very high e. m. f. measurements. Accuracy of needle-gap measurements and effect of degree of sharpness thereon.

## A NEW INSTRUMENT FOR THE MEASUREMENT OF ALTERNATING CURRENTS

E. F. Northrup

Vol. xxiv—1905, pp. 741-757

Description of the construction and mode of operation of a hot-wire instrument devised for zero measurements of either alternating current or direct current, together with analytical discussion of the mode of adjustment for different kinds of work.

*Discussion*, pp. 758-760, by Messrs. E. F. Northrup, H. G. Stott, F. N. Waterman and H. W. Fisher.

General remarks concerning the probable limitations of the instruments.

## THREE-PHASE POWER FACTOR

Austin Burt

Vol. xxvii—1908, pp. 801-814

Derivation of formula for the mean power-factor of a three-phase system, together with a method of determining power-factor from wattmeter readings.

*Discussion*, pp. 815-817, by Messrs. Comfort A. Adams, Frederick Bedell, H. L. Wallau and B. A. Behrend.

Physical demonstration of the two-wattmeter method of determining three-phase power factor.

## METHOD OF TESTING TRANSFORMER CORE LOSSES GIVING SINE WAVE RESULTS ON COMMERCIAL CIRCUITS

L. W. Chubb

Vol. xxviii—1909, pp. 417-431

The use, construction and limits of accuracy of a special instrument—iron-loss voltmeter—consisting of a wattmeter connected in series with an exciting winding on a steel core and calibrated to read the impressed voltage of sine wave e. m. f. Also a description of a method of adjusting form factor in core-loss tests.

*Discussion*, pp. 432-438, by Messrs. Frederick Bedell, Charles P. Steinmetz, M. G. Lloyd, L. T. Robinson, Charles F. Scott and L. W. Chubb.

General discussion of the use and limitations of iron-loss voltmeter. Description of a method for obtaining sine wave from a commercial circuit.

## C. NON-ELECTRICAL MEASUREMENTS AND INSTRUMENTS

## ANGULAR VARIATIONS IN STEAM ENGINES

P. O. Keilholtz

Vol. xviii—1901, pp. 703-740

Mathematical investigation of the turning moments due to steam and to inertia of the reciprocating parts, developing method of determining the relation between balancing effect of fly-wheel and the deviation from the position of absolutely uniform speed. Description of method of measuring any velocity variations by means of electrically driven tuning fork with detailed results of tests on a tandem compound engine.

*Discussion*, incorporated with that of paper by Walter I. Slichter on "Angular Velocity in Steam Engines in Relation to Paralleling of Alternators."

## AN INTEGRATING PHOTOMETER FOR GLOW LAMPS AND SOURCES OF LIGHT INTENSITY

Chas. P. Matthews

Vol. xx—1902, pp. 59-70

Theory, design, construction and operation of a special intensity photometer invented by the author for use in making photometric measurements of incandescent lamps and flames.

*Discussion*, incorporated with that of paper by Clayton H. Sharp on "The Commercial Accuracy of Photometrical Measurements."

## SOME METHODS OF PHOTOMETRY AS APPLIED TO INCANDESCENT LAMPS

J. T. Marshall

Vol. xx—1902, pp. 77-85

A description of method of calibrating and using sliding scale photometer for commercial testing and inspection of incandescent lamps.

*Discussion*, incorporated with that of paper by Clayton H. Sharp on "The Commercial Accuracy of Photometrical Measurements."

## THE COMMERCIAL ACCURACY OF PHOTOMETRICAL MEASUREMENTS

Clayton H. Sharp

Vol. xx—1902, pp. 87-93

Experimental investigation of the limits of accuracy in different classes of photometrical measurements.

*Discussion* (including that of paper by Chas. P. Matthews on "Integrating Photometer for Glow Lamps and Sources of Light Intensity"; paper by Douglass Burnett on "Distributed Lighting"; and paper by J. T. Marshall on "Some Methods of Photometry as Applied to Incandescent Lamps"), pp. 94-110, by Messrs. Douglass Burnett, Edward L. Nichols, Francis R. Upton, L. B. Marks, W. S. Howell, F. S. Smith, Edward B. Rosa, Calvin W. Rice, William J. Hammer, W. S. Stratton, Clayton H. Sharp, J. T. Marshall, Chas. F. Scott, Chas. P. Matthews, Edward P. Thompson, Alex J. Wurts, R. H. Henderson, Max Von Reckinghausen, P. M. Lincoln, N. W. Storer and F. W. Jones.

Merits of mean spherical candle-power method of rating illuminants. Methods of measuring illumination. Description of Cooper-Hewitt mercury vapor lamp.

## MEASUREMENT OF TEMPERATURE BY ELECTRICAL MEANS

Edwin F. Northrup

Vol. xxv—1906, pp. 473-504

Theory, construction and connections for resistance pyrometers, profusely illustrated with drawings and connection diagrams.

*Discussion*, pp. 505-506, by Mr. E. F. Schuetz.

A NEW CO<sub>2</sub> RECORDER

C. O. Mailloux

Vol. xxvi—1907, pp. 1771-1787

Description of Orsat apparatus followed by detailed description of the Westover recorder.

*Discussion*, p. 1788, by A. A. Adler.

## THE MEASUREMENT OF ROTARY SPEEDS OF DYNAMO MACHINES BY THE STROBOSCOPIC FORK

A. E. Kennelly and S. E. Whiting

Vol. xxvii—1908, pp. 631-646

Brief historical outline of stroboscopic fork and its use with special reference to the work of Dr. Chas. V. Drysdale, followed by a description of the construction and mode of operation of a new modification of the instrument arranged for portable work.

*Discussion*, pp. 647-649, by Messrs. J. B. Taylor, C. A. Perkins, C. H. Sharp and A. E. Kennelly.

Range of speed obtained with ordinary stroboscopic fork.

## NOTE ON A SIMPLE DEVICE FOR FINDING THE SLIP OF AN INDUCTION MOTOR

Charles A. Perkins

Vol. xxiv—1905, pp. 879-880

Description of device.

## D. INSTRUMENT TRANSFORMERS

## THE CURRENT TRANSFORMER

Kenneth L. Curtis

Vol. xxv—1906, pp. 715-726

Method of predetermining the performance of series transformer from tests of exciting current and internal losses. Method of measuring small inductances.

*Discussion*, pp. 727-734, by Mr. L. T. Robinson.

Testing of series transformer for ratio and phase angle. Oscillograms of exciting current of series transformers.

## ELECTRICAL MEASUREMENTS ON CIRCUITS REQUIRING CURRENT AND POTENTIAL TRANSFORMERS

L. T. Robinson

Vol. xxxviii—1909, pp. 1005-1039

Theoretical discussion of the effects of instrument transformers on the accuracy of ammeter and wattmeter measurements, together with tables of correction factors for phase angle error in power measurements. Theory of operation of series transformer showing effects of variation in frequency, secondary impedance, line current, power-factor and wave form. Description of methods of testing series and shunt instrument transformers with ratio and phase angle performance curves from actual test.

*Discussion*, pp. 1040-1052, by Messrs. C. H. Sharp, M. G. Lloyd, L. W. Chubb, J. Dalemont, Albert F. Ganz and L. T. Robinson.

Methods of measuring ratio and phase angle of current transformers and correction factor for instrument transformers in polyphase measurements.

## SOME RECENT DEVELOPMENTS IN EXACT ALTERNATING-CURRENT MEASUREMENTS

Clayton H. Sharp and William W. Crawford

Vol. xxix—1910, pp. 1517-1541

Description of design and construction of various precision devices—synchronous reversing key, adjustable mutual inductance, phase shifter and heavy current non-inductive shunt—showing their application in the accurate measurement of ratio and phase angle of series and shunt instrument transformers and in an alternating-current potentiometer.

*Discussion*, pp. 1542-1552, by Messrs. V. Karapetoff, L. T. Robinson, W. H. Pratt, C. P. Steinmetz, Clayton H. Sharp and William W. Crawford.

General remarks on precision measurements of alternating-current quantities. Description of a water-cooled electro-dynamometer, also of a method of measuring very high frequency alternating current.



## 4. DIELECTRICS AND DIELECTRIC PHENOMENA

### STATIC STRAINS IN HIGH-TENSION CIRCUITS AND THE PROTECTION OF APPARATUS

Percy H. Thomas

Vol. xix—1902, pp. 213-264

Discussion of the nature, causes and effects of disturbances of the potential in a transmission system, such as occur when switches are opened or closed, grounds, short circuits, etc. Description of the mode of operation of the static interrupter and the spark gap lightning arrester with series and shunt resistors. Experimental study of the effects of static disturbances and the degree of protection afforded by choke coils and static interrupters. Description of mechanical model for demonstrating the travel of waves over a transmission line.

*Discussion*, pp. 265-276, by Messrs. C. P. Steinmetz, F. O. Blackwell, H. W. Fisher, Philip Torchio, P. H. Thomas and B. A. Behrend.

Results of investigation of needle gap, showing the effect of sharpness on sparking distance; also results of experimental investigation of high-tension transmission line, showing the effects of switching with oil and air-break switches. Mathematical study of distribution of potential stress in model as to time and distance measured from time and position of application.

### ENERGY LOSS IN COMMERCIAL INSULATING MATERIALS WHEN SUBJECTED TO HIGH-POTENTIAL STRAINS

Charles Edward Skinner

Vol. xix—1902, pp. 1047-1062

Experimental study of energy losses in dielectrics, showing the effects of variation in voltage, temperature, moisture and frequency. The exact nature of the dielectric not given. Test of energy losses in 5,000-kilowatt engine type alternator of Manhattan Railway Company.

*Discussion* (including that of paper by Percy H. Thomas on "The Function of Shunt and Series Resistance in Lightning Arresters," and paper by Miles Walker on "Electrostatic Wattmeter in Commercial Measurements"), pp. 1063-1073, by Messrs. Edw. L. Nichols, Chas. F. Hopewell, Chas. E. Skinner, W. S. Andrews, F. A. C. Perrine, Elihu Thompson, William Maver, Jr., P. B. Woodworth, C. P. Steinmetz and P. H. Thomas. Observed dielectric strength of mica under oil. Electrolytic conduction in cable insulation. Effect of moisture on dielectric strength of oil. General remarks on lightning arresters.

### SOME RECOMMENDATIONS CONCERNING ELECTRICAL AND MECHANICAL SPECIFICATIONS OF TROLLEY INSULATORS

Samuel Sheldon & John D. Kelley

Vol. xxii—1903, pp. 231-239

Description of methods and results of testing strain insulators for tensile strength, breakdown e. m. f., insulation resistance and determination of maximum working temperature for round top trolley suspension

insulators. Specifications for various forms of insulators for overhead trolley construction.

*Discussion*, pp. 240-242, by Messrs. Joseph Sachs, Ralph D. Mershon and Samuel Sheldon.

Recommendations for standard railway insulator specifications. Alternating current vs direct current for testing insulators for use on direct current circuits.

#### THE TESTING OF ELECTRICAL APPARATUS FOR DIELECTRIC STRENGTH

P. H. Thomas

Vol. xxii—1903, pp. 353-360

Brief discussion of the difficulties and dangers of testing dielectrics, followed by a list of precautions and general recommendations for making such tests.

*Discussion*, pp. 361-371, by Messrs. L. A. Hawkins, M. H. Gerry, Jr., H. G. Stott, J. S. Peck, P. M. Lincoln, Gano S. Dunn, P. H. Thomas, W. L. Waters, C. E. Skinner, Ralph D. Mershon, A. S. Langsdorf, Henry Pikler, Louis Bell and P. G. Gossler.

General discussion of dielectric testing; methods of voltage application and measurement; duration of test; effect of fatigue; choice of value of test voltage, etc. Wave distortion due to resistor in series with transformer. Experience with overhead grounded wire.

#### ELECTRIC CABLES FOR HIGH VOLTAGE SERVICE

Henry W. Fisher

Vol. xxii—1903, pp. 417-420

Brief discussion of requirements to be met in the manufacture, installation and operation of rubber and paper insulated cables.

*Discussion*, incorporated with that of paper by H. G. Stott on "The Use of Automatic Means for Disconnecting Disabled Apparatus."

#### THE CONDUCTIVITY OF THE ATMOSPHERE AT HIGH VOLTAGES

Harris J. Ryan

Vol. xxiii—1904, pp. 101-134

Analytical discussion of corona phenomena, reviewing previous experiments of the author and others, followed by account of experimental investigation of corona losses in the laboratory with a cathode tube wave tracer, showing effects of conductor dimensions and atmospheric conditions upon critical voltage, all of which are expressed in equation for critical e. m. f.

*Discussion*, pp. 135-145 and 168-170, by Messrs. C. F. Scott, Samuel Sheldon, Harold B. Smith, P. H. Thomas, Harris J. Ryan, P. M. Lincoln, G. T. Hanchett, Elihu Thomson, Ralph D. Mershon, S. M. Kintner, H. W. Fisher, W. A. Blanck and C. E. Freeman.

General remarks on losses to atmosphere at high e. m. f.'s., with special reference to the critical e. m. f. and the factors which affect it. Difficulties in measuring very high e. m. f.'s.

## TERMINALS AND BUSHINGS FOR HIGH-PRESSURE TRANSFORMERS

Walter S. Moody

Vol. xxiii—1904, pp. 225-230

Location, arrangement and insulation of transformer terminals.

*Discussion*, pp. 23-235, by Messrs. Ralph D. Mershon, C. E. Skinner, Irving A. Taylor, N. M. Snyder, A. C. Pratt.

General remarks on transformer terminals and terminal bushings. Weak spots in construction of transformer terminals, taps and bushings. Bushing treated as a condenser.

## DATA RELATING TO ELECTRIC CONDUCTORS AND CABLES

H. W. Fisher

Vol. xxiv—1905, pp. 397-414

Experimental study of the safe current-carrying capacity of insulated wires and cables. Effect of steel strands on cable impedance and method of overcoming it. Table of reactances for different sizes of wire and cables at different spacings. Tests of variation of insulation resistance and electrostatic capacity with temperature and of the heating of cables in ducts.

*Discussion*, pp. 415-419, by Messrs. H. G. Stott, C. W. Rice, C. O. Mailoux, Charles P. Steinmetz and H. W. Fisher.

Conditions under which high-reactance cable is desirable.

## STANDARDIZING RUBBER-COVERED WIRES AND CABLES

John Langan

Vol. xxv—1906 pp. 191-204

Protest against potential test as a criterion of insulation. Characteristics and properties of different grades of rubber, with instructions for easily determining the quality of rubber insulation. Suggested specifications for rubber-covered wires.

*Discussion*, incorporated with paper by Wallace S. Clark on "Comments on Present Underground Cable Practice."

## COMMENTS ON PRESENT UNDERGROUND CABLE PRACTICE

Wallace S. Clark

Vol. xxv—1906, pp. 205-213

Notes on electrolysis troubles with the low-tension cables. Effect of grounding sheath. Properties of insulation, tests of durability and record of operation of 11,000-volt 25-cycle rubber-covered leaded cables. Specifications of Rubber-Covered Wire Engineers' Association for 30 per cent. rubber compound.

*Discussion* (included with paper by John Langan on "Standardizing Rubber-Covered Wires and Cables"), pp. 214-239, by Messrs. H. W. Fisher, H. G. Stott, Wallace D. Clark, John Langan, Philip Torchio, A. E. Kennelly, E. W. Stevenson, Townsend Wolcott, Durand Woodman, William McClellan, J. B. Taylor, C. F. Scott, S. S. Wheeler, Dugald C. Jackson, F. R. Cutcheon, J. H. Schumacher, H. J. Gille, John Pearson and E. H. Scofield.

General discussion of the requirements of rubber insulation and the

methods of fixing and testing them. Results of tests on rubber insulated wires showing effect of percentage of Para on the performance characteristics under different conditions and indicating the method of determining the quality of insulation.

#### THE HEATING OF COPPER WIRES BY ELECTRIC CURRENTS

A. E. Kennelly & E. R. Shepard

Vol. xxvi—1907, pp. 969-995

Experimental investigation of the heating of wires under various conditions of cooling by thermal conduction—through insulation, sand, water, and molding. Much data on thermal resistivity of insulation materials, wood and various soils. Graphical diagrams of the current carrying capacity of different sized wires under the various conditions.

No discussion.

#### POWER-FACTOR, ALTERNATING-CURRENT INDUCTIVE CAPACITY, CHEMICAL AND OTHER TESTS OF RUBBER-COVERED WIRES OF DIFFERENT MANUFACTURERS

Henry W. Fisher

Vol. xxvi—1907, pp. 997-1020

Experimental investigation tending to show the relations that exist between the chemical composition of the rubber compound and the electrical properties of the wire—breakdown e. m. f.; insulation resistance; capacity; power-factor, and dielectric loss. Full results and test data are given in form of tables and graphical charts.

*Discussion*, pp. 1021-1025, by Messrs. Henry W. Fisher, Charles P. Steinmetz, E. W. Stevenson and Henry G. Stott.

General remarks on dielectric properties of cables.

#### HIGH-VOLTAGE MEASUREMENTS AT NIAGARA

Ralph D. Mershon

Vol. xxvii—1908, pp. 845-903

Detailed account of tests on high-tension lines, covering the losses of line to atmosphere by corona, leakage over insulators, etc., with various spacings, conductor diameters, frequencies and atmospheric conditions; also the effect of the various factors in the occurrence of the critical voltage. Most data is presented in graphic form. In conclusion there are 22 items that have a distinct bearing upon the operation of very high-tension lines, and which have been deduced from the results of these tests and those made at Telluride and by Professor Ryan.

*Discussion*, pp. 904-929, by Messrs. Henry Doherty, Elihu Thomson, Samuel Sheldon, Henry Floy, Chas. P. Steinmetz, Percy H. Thomas, P. M. Lincoln, Carl Hering, Chas. F. Scott, A. E. Kennelly, W. I. Waters and N. M. Snyder.

General discussion of line and insulator losses at high tension. Definition of critical point and explanation of physical meaning of relation between atmospheric losses and vapor product. Analysis of insulator losses.

## THE TESTING OF HIGH-VOLTAGE LINE INSULATORS

C. E. Skinner

Vol. xxvii—1908, pp. 945-951

Proposed specifications for routine and design testing of high-tension line insulators.

*Discussion*, pp. 952-958, by Messrs. Percy H. Thomas, Ralph D. Mer-shon, Clayton H. Sharp, E. M. Hewlett, Chas. P. Steinmetz, C. E. Skinner and N. J. Neall.

General remarks on insulator test specifications, with special reference to methods of making the rain test.

## CONDENSER TYPE OF INSULATION FOR HIGH-TENSION TERMINALS

A. B. Reynnders

Vol. xxviii—1909, pp. 209-220

Theory, construction and tests of special form of high-tension terminal bushing built with alternate layers of metal foil and insulation.

*Discussion* (including that of K. C. Randall's paper on "High-Tension Transformers and Protective and Controlling Apparatus for Outdoor Installation"), pp. 221-268, by Messrs. W. S. Moody, Percy H. Thomas, David B. Rushmore, Paul M. Lincoln, E. M. Hewlett, S. Piek, Guido Semenza, A. E. Kennelly, J. S. Peck, Ralph D. Mer-shon, W. S. Franklin, N. J. Neall, G. Faccioli, C. L. de Muralt, V. D. Moody, M. W. Franklin, K. C. Reynnders, Ralph W. Pope, F. G. Baum, O. S. Lyford, Jr., Carl Schwartz, J. B. Whitehead, John J. Frank, W. L. Waters, L. L. Perry, J. N. Kelman, August H. Kruesi and D. Kos.

General discussion of the advisability of using outdoor transformer and switching stations. Experience with outdoor high-tension apparatus. Theory and calculation of condenser type bushings. Construction of oil and asphalt filled insulating bushings.

## CORONA PHENOMENA IN AIR AND OIL AND THEIR RELATION TO TRANSFORMER DESIGN

W. S. Moody and G. Faccioli

Vol. xxviii—1909, pp. 769-798

Theoretical and experimental investigation of corona formation in apparatus of limited dimensions in air and in oil, showing the effect of character of surface, insulating masses, conductor masses, dimensions of conductor, etc.

*Discussion*, pp. 799-804, by Messrs. John B. Whitehead, J. C. Lincoln, Ralph D. Mer-shon, S. B. Charters, Jr., W. S. Moody and Harris J. Ryan.

Dielectric strength and conducting character of air. Mechanical strains due to corona under oil. Description of Ryan's corona voltmeter.

## THE APPLICATION OF PORCELAIN TO STRAIN INSULATORS

W. H. Kempton

Vol. xxix—1910, pp. 967-974

Brief account of tests on several different types of strain insulators, giving the ultimate shearing, tensile and compressive stresses.

*Discussion*, incorporated with that of paper by W. N. Smith on "Electric Railway Catenary Trolley Construction."

## DISRUPTIVE STRENGTH WITH TRANSIENT VOLTAGES

Joseph L. R. Hayden and Charles P. Stienmetz

Vol. xxix—1910, pp. 1125-1158

Account of experimental investigation of the effects of time and energy on the dielectric strength of air and oil. Full description of the method of testing and analysis of results. Characteristic curves of the dielectric strength of air and oil with different shaped electrodes, showing effect of duration of stress and of the energy behind the stress. Empirical equations.

*Discussion*, incorporated with that of H. W. Tobey's paper on "Dielectric Strength of Oil."

## THE ELECTRIC STRENGTH OF AIR

J. B. Whitehead

Vol. xxix—1910, pp. 1159-1187

Description and discussion of an experimental investigation of the dielectric strength of air and the formation of corona around cylindrical conductors, showing effects of temperature, pressure, and dimensions and material of the wire in dielectric strength of air. Description of a new and very accurate method of testing dielectric strength of air about conductors. Bibliography.

*Discussion*, incorporated with that of H. W. Tobey's paper on "Dielectric Strength of Oil."

## DIELECTRIC STRENGTH OF OIL

H. W. Tobey

Vol. xxix—1910, pp. 1189-1207

Description of the properties of insulating oils and methods of testing and handling such oils. Tests showing effects of form of electrode, temperature and moisture on dielectric strength of oils, with characteristic curves. Analytical and experimental study of methods of drying and filtering oil.

*Discussion* (including that of paper by Messrs. Joseph L. R. Hayden and Charles P. Steinmetz on "Disruptive Strength with Transient Voltages," and Mr. J. B. Whitehead's paper on "The Electric Strength of Air"), pp. 1208-1232, by Messrs. D. B. Rushmore, V. Karapetoff, Percy H. Thomas, A. E. Kennelly, W. H. Pratt, E. E. F. Creighton, J. C. Lincoln, Charles F. Scott, Harris J. Ryan, R. D. Mershon, C. P. Steinmetz, John B. Whitehead and M. A. de Chatelain.

General comments on the results of the tests, with various suggested explanations of the phenomena of corona, and relation of diameter of the conductor and other factors to the apparent dielectric strength of air.

## POTENTIAL STRESSES IN DIELECTRICS

Harold S. Osborne

Vol. xxix—1910, pp. 1553-1581

General résumé of work done in developing graded insulation for cables with derivation of formulas and construction of various sets of curves from which the best designs for graded cables can be read directly. Analytical discussion of phenomena immediately preceding dielectric

breakdown—corona in solid dielectrics—giving opinions of many eminent authorities, followed by a suggested explanation which is checked by tests. Bibliography.

*Discussion*, pp. 1582-1624, by Messrs. J. B. Whitehead, Milton Franklin, A. E. Kennelly, W. S. Franklin, W. I. Middleton, Henry A. Morss, R. W. Atkinson, H. W. Fisher, Percy Thomas, C. J. Fechheimer, G. I. Rhodes, Armin Henry Pikler, C. P. Steinmetz, C. O. Mailloux, Tracy D. Waring, William A. Del Mar and H. S. Osborne.

General discussion of graded insulation as applied to cables, generators and transformers, and also of the phenomena that precede breakdown in solid dielectrics. Formulas and experimental results bearing on the design of insulation. Effect of grading on the maximum safe kilowatt capacity of cables.

## 5. ELECTRIC CONDUCTORS

### LOCATING FAULTS IN UNDERGROUND DISTRIBUTION SYSTEMS

Henry G. Stott

Vol. xviii—1901, pp. 829-833

Description of a compass method for quickly and accurately locating faults in power cables through which periodically reversed current is sent. Working drawings of the current reverser.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

### SUBMARINE CABLE TESTING IN THE SIGNAL CORPS U. S. ARMY

Vol. xix—1902, pp. 685-695

General description of the electrical and mechanical specifications for Signal Corps cable and the tests which it must undergo. Change of insulation resistance with temperature treated in detail, and a chart given for reducing resistances to standard temperatures.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

### THE OPERATION AND MAINTENANCE OF HIGH-TENSION UNDERGROUND SYSTEM

Philip Torchio

Vol. xxli—1903, pp. 421-425

Brief remarks on the general subject. Record of cable troubles on The New York Edison Company lines. Connections of apparatus for breaking down defective insulation.

*Discussion*, incorporated with that of paper by H. G. Stott on "The Use of Automatic Means for Disconnecting Disabled Apparatus."

### THE ELECTRICAL CONDUCTIVITY OF COMMERCIAL COPPER

Lawrence Addicks

Vol. xxii—1903, pp. 695-702

Experimental study of the relation between chemical composition, mechanical strength, physical structure and conductivity of copper.

*Discussion*, p. 703, by Messrs. B. J. Arnold and F. J. Newbury.

Properties of standard copper conductors.

### SAFETY DEVICES IN CENTRAL STATIONS AND SUBSTATIONS

Philip Torchio

Vol. xxi—1903, pp. 417-423

Itemized list of expedients to be employed in large central station system to insure the maximum degree of reliability of service.

*Discussion*, incorporated with that of paper by Peter Junkersfeld on "Multiple Versus Independent Operation of Units and Central Stations."

### PROTECTION OF CABLES FROM ARCS DUE TO THE FAILURE OF ADJACENT CABLES

W. G. Carlton

Vol. xxliii—1904, pp. 471-474

Description of methods of isolating and fire-proofing cables in man-holes.



*Discussion*, pp. 475-479, by Messrs. Ralph D. Mershon, W. F. Wells, H. C. Wirt, W. G. Carlton, H. B. Alverson, E. M. Lake, A. M. Hunt and J. W. F. Blizard.

General remarks on the protection of high-tension cables in manholes and in power houses. Formulas for fire-proof coverings.

#### HIGH-POWER SURGES IN ELECTRIC DISTRIBUTION SYSTEMS OF GREAT MAGNITUDE

Charles P. Steinmetz

Vol. xxiv—1905, pp. 297-315

Theoretical and mathematical investigation of high-power surge in Manhattan Railway cable distribution system.

*Discussion*, incorporated with paper by Percy H. Thomas on "An Experimental Study of the Rise of Potential on Commercial Transmission Lines Due to Static Disturbances caused by Switching, Grounding, Etc."

#### DATA RELATING TO ELECTRIC CONDUCTORS AND CABLES

H. W. Fisher

Vol. xxiv—1905, pp. 397-414

Experimental study of the safe current-carrying capacity of insulated wires and cables. Effect of steel strands on cable impedance and method of overcoming it. Table of reactances for different sizes of wire and cables at different spacings. Tests of variation of insulation resistance and electrostatic capacity with temperature and of the heating of cables in ducts.

*Discussion*, pp. 415-419, by Messrs. H. G. Stott, C. W. Rice, C. O. Mailloux, Charles P. Steinmetz and H. W. Fisher.

Conditions under which high-reactance cable is desirable.

#### STANDARDIZING RUBBER-COVERED WIRES AND CABLES

John Langan

Vol. xxv—1906, pp. 191-204

Protest against potential test as a criterion of insulation. Characteristics and properties of different grades of rubber, with instructions for easily determining the quality of rubber insulation. Suggested specifications for rubber-covered wires.

*Discussion*, incorporated with paper by Wallace S. Clark on "Comments on Present Underground Cable Practice."

#### COMMENTS ON PRESENT UNDERGROUND CABLE PRACTICE

Wallace S. Clark

Vol. xxv—1906, pp. 205-213

Notes on electrolysis troubles with the low-tension cables. Effect of grounding sheath. Properties of insulation, tests of durability and record of operation of 11,000-volt 25-cycle rubber-covered leaded cables. Specifications of Rubber Covered Wire Engineers' Association for 30 per cent. rubber compound.

*Discussion* (included with paper by John Langan on "Standardizing

Rubber Covered Wires and Cables"), pp. 214-239, by Messrs. H. W. Fisher, H. G. Stott, Wallace D. Clark, John Langan, Philip Torchio, A. E. Kennelly, E. W. Stevenson, Townsend Wolcott, Durand Woodman, William McClellan, J. B. Taylor, C. F. Scott, S. S. Wheeler, Dugald C. Jackson, F. R. Cutcheon, J. H. Schumacher, H. J. Gille, John Pearson and E. H. Scofield.

General discussion of the requirements of rubber insulation and the methods of fixing and testing them. Results of tests on rubber insulated wires showing effect of percentage of Para on the performance characteristics under different conditions and indicating the method of determining the quality of insulation.

#### UNDERGROUND TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY

Charles E. Phelps

Vol. xxvi—1907, pp. 25-30

Classification of cable faults, followed by seven-year record of the performance of various kinds of power, telephone and telegraph cables. Brief analytical discussion of the causes and remedies for these various faults.

No discussion.

#### CONSTANTS OF CABLES AND MAGNETIC CONDUCTORS

Ernst J. Berg

Vol. xxvi—1907, pp. 555-568

Derivation of equations for inductance and capacity of parallel conductors, followed by an analysis of single-conductor cable performance under various conditions. Estimated effective resistance and reactance with grounded and ungrounded sheath and with iron armor; also estimated effective resistance of iron wire and cable.

*Discussion*, p. 926, by Mr. W. A. Del Mar.

Exact formula for inductance of parallel wires.

#### THE HEATING OF COPPER WIRES BY ELECTRIC CURRENTS

A. E. Kennelly and E. R. Shepard

Vol. xxvi—1907, pp. 969-995

Experimental investigation of the heating of wires under various conditions of cooling by thermal conduction—through insulation, sand, water and molding. Much data on thermal resistivity of insulation materials, wood and various soils. Graphical diagrams of the current carrying capacity of different sized wires under the various conditions.

No discussion.

#### POWER-FACTOR, ALTERNATING-CURRENT INDUCTIVE CAPACITY, CHEMICAL, AND OTHER TESTS OF RUBBER-COVERED WIRES OF DIFFERENT MANUFACTURERS

Henry W. Fisher

Vol. xxvi—1907, pp. 997-1020

Experimental investigation tending to show the relations that exist between the chemical composition of the rubber compound and the electrical properties of the wire—breakdown e. m. f., insulation resistance,

capacity, power-factor, and dielectric loss. Full results and test data are given in form of tables and graphical charts.

*Discussion*, pp. 1021-1025, by Messrs. Henry W. Fisher, Charles P. Steinmetz, E. W. Stevenson and Henry G. Stott.

General remarks on dielectric properties of cables.

#### CONDUCTOR RAIL MEASUREMENTS

S. B. Fortenbaugh

Vol. xxvii—1908, pp. 1215-1229

Results of tests on Metropolitan District Railway third and fourth rail conductors, giving leakage and insulation difficulties under various conditions of service; also complete data on resistance tests made on conductor rails.

No discussion.

#### HIGH-POTENTIAL UNDERGROUND TRANSMISSION

P. Junkersfeld and E. O. Schweitzer

Vol. xxvii—1908, pp. 1499-1527

Description of the underground cable system of the Commonwealth Edison Company of Chicago with records of its performance and results of experiments to determine the magnitude and frequency of occurrence of potential rises in the system.

*Discussion*, pp. 1528-1569, by Messrs. L. A. Ferguson, Charles H. Merz, H. W. Fisher, H. G. Stott, E. J. Berg, Wallace S. Clark, Alex Dow, Warren Partridge, E. E. F. Creighton, L. T. Robinson, Henry Floy, John W. Lieb, Jr., Philip Torchio, Charles P. Steinmetz, E. O. Schweitzer, Peter Junkersfeld, Ralph D. Mershon, H. W. Peck, A. E. Kennelly, N. J. Neall, L. L. Elden, M. V. Ayres, G. W. Palmer, Jr., and Dugald C. Jackson.

Cable experience of various large central stations and transmission companies.

#### THE CONVECTION OF HEAT FROM SMALL COPPER WIRES

A. E. Kennelly, C. A. Wright and J. S. Bylevelt

Vol. xxviii—1909, pp. 363-393

Experimental investigation of convection from wires—varying diameter, air pressure and wind velocity.

*Discussion*, pp. 394-397, by Messrs. V. Karapetoff, Charles P. Steinmetz, Charles F. Scott, Paul M. Lincoln and A. E. Kennelly.

Remarks on nomenclature for absolute units.

#### RESISTANCE AND REACTANCE OF ARMORED CABLES

J. B. Whitehead

Vol. xxviii—1909, pp. 737-746

Calculation and tests of effective impedance and reactance of single and double-conductor iron and copper-armored cable under various conditions of current density, spacing, interconnection of armor and sheathing, etc.

*Discussion*, incorporated with that of Mr. H. W. Fisher's paper on "Losses, Induced Volts and Amperes in Armor and Lead Cover of Cables."

## LOSSESS, INDUCED VOLTS AND AMPERES IN ARMOR AND LEAD COVER OF CABLES

H. W. Fisher

Vol. xxviii—1909, pp. 747-765

Tests of impedance, reactance, resistance and induced current and volts in the sheath and armor of single-conductor iron-armored, copper-armored and steel-tape armored cables, showing the effect of spacing, current density, cross-bonding of sheath and armor, etc. Graphical method of calculating the performance of such cables.

*Discussion*, pp. 766-767, including the discussion of Mr. J. B. Whitehead's paper on "Resistance and Reactance of Armored Cables," by Messrs. Ralph D. Mereshon, H. W. Fisher, John B. Whitehead and Charles P. Steinmetz.

General discussion of the advisability of using single-conductor cables in alternating-current power transmission.

## POTENTIAL STRESSES IN DIELECTRICS

Harold S. Osborne

Vol. xxix—1910, pp. 1553-1581

General résumé of work done in developing graded insulation for cables with derivation of formulas and construction of various sets of curves from which the best designs for graded cables can be read directly. Analytical discussion of phenomena immediately preceding dielectric breakdown—corona on solid dielectrics—giving opinions of many eminent authorities, followed by a suggested explanation which is checked by tests. Bibliography.

*Discussion*, pp. 1582-1624, by Messrs. J. B. Whitehead, Milton Franklin, A. E. Kennelly, W. S. Franklin, W. I. Middleton, Henry A. Morss, R. W. Atkinson, H. W. Fisher, Percy Thomas, C. J. Fechheimer, G. I. Rhodes, Armin Henry Pikler, C. P. Steinmetz, C. O. Mailloux, Tracy D. Waring, William A. Del Mar and H. S. Osborne.

General discussion of graded insulation as applied to cables, generators and transformers, and also of the phenomena that precede breakdown in solid dielectrics. Formulas and experimental results bearing on the design of insulation. Effect of grading on the maximum safe kilowatt capacity of cables.

## 6. MAGNETIC PROPERTIES AND TESTING OF IRON

### THE FACTORS WHICH AFFECT THE ENERGY LOSSES IN ARMATURE CORES

J. Walter Esterline and C. E. Reid

Vol. xxii—1903, pp. 445-460

Description of apparatus for experimental investigation of armature core losses. Analysis of core losses and results of tests showing effect of teeth, core section, solid poles, laminated poles and other factors on such losses.

*Discussion*, pp. 461-466, by Messrs. J. W. Esterline, Henry Pickler, W. E. Goldsborough, W. S. Franklin, Leonard Wilson, C. O. Mailloux and A. E. Kennelly.

Effect of number of poles and of pole arc upon armature core losses.

### MAGNETIC PROPERTIES OF ELECTROLYTIC IRON

F. C. Burgess and A. Hoyt Taylor

Vol. xxv—1906, pp. 459-465

Some chemical and physical properties of electrolytic iron. Method and results of step by step magnetization and hysteresis tests.

*Discussion*, pp. 466-471, by Messrs. E. F. Northrup, D. C. Jackson, Chas. F. Scott, W. L. R. Emmett, C. P. Steinmetz, C. F. Burgess and R. A. Fessenden.

Magnetic alloys that do not contain iron.

### THE EFFECT OF IRON IN DISTORTING ALTERNATING-CURRENT WAVE FORM

Frederick Bedell and Elbert B. Tuttle

Vol. xxv—1906, pp. 671-691

Theoretical investigation of the relation between the third harmonic introduced by iron in the exciting current and the hysteresis loop. Also, an exposition of the relation between the area of the hysteresis loop and the angle of hysteresis advance.

*Discussion*, pp. 692-714, by Messrs. Chas. P. Steinmetz, Philip Torchio, W. S. Franklin, Frederick Bedell, Harold Pender, A. Henry Pikler, S. P. Grace, H. B. Tuttle, S. N. Kintner and A. W. Copley.

Full discussion of wave distortion due to iron, showing that other harmonics than the third modify Professor Bedell's conclusions. References to early work of Huguët, Froelich, Kennelly, Gerosa, Finzi, Eickemeyer and Steinmetz.

Effect of wave distortion with different polyphase transformer connections. Derivation of the parabolic law of magnetic induction. Oscillograms of induced e.m.f. showing effect of primary impedance on wave form in core loss tests and in transformers.

### THE TESTING OF TRANSFORMER STEEL

M. G. Lloyd and J. V. S. Fisher

Vol. xxviii—1909, pp. 439-467

Conditions and requirements of the wattmeter method of core-loss testing, with description of Bureau of Standards modification of Epstein

apparatus. Analysis of core losses and results of tests on large variety of transformer steels.

*Discussion*, pp. 468-473, by Messrs. L. T. Robinson, V. Karapetoff, C. E. Skinner, J. C. Lincoln, Clayton H. Sharp, Andrew Pinkerton, E. E. F. Creighton and M. G. Lloyd.

Discussion of the relative value of Bureau of Standards method and the Epstein method for commercial testing. Relation of magnetizing current to transformer regulation.

#### CALCULATION OF IRON LOSSES IN DYNAMO ELECTRIC MACHINERY

I. E. Hanssen

Vol. xxviii—1909, pp. 993-1001

Experimental study of stream lines in various types of armatures, with a simple method for pre-determining the total iron loss.

*Discussion*, pp. 1002-1004, by Messrs. R. E. Hellmund, A. E. Averett, V. Karapetoff and I. E. Hanssen.

Remarks on the accuracy of the author's method.

#### POLE-FACE LOSSES

C. A. Adams, A. C. Lanier, C. C. Pope and C. O. Schooley Vol. xxviii—1909, pp. 1133-1156

Theoretical and experimental investigation of pole-face losses, establishing quantitative relations between such losses and the principal variables for both solid and laminated pole shoes. Comparison of calculated losses with test values.

No discussion.

## 7. BATTERIES

### THE NEW EDISON STORAGE BATTERY

Arthur E. Kennelly

Vol. xviii—1901, pp. 219-230

Description of the battery, its advantages and mechanical construction. Performance data obtained from Mr. Edison.

*Discussion*, pp. 231-246, by Messrs. A. E. Kennelly, N. S. Keith, Charles P. Steinmetz, Robert McA. Lloyd, Carl Hering, C. O. Mailloux, H. G. Stott, Justus Entz, Charles J. Reed and H. E. Heath.

Principal disadvantages of the nickel-iron cell. Further performance data.

### THE STORAGE BATTERY AS A FACTOR IN SPEED CONTROL

H. P. Coho

Vol. xx—1902, pp. 135-138

Brief description of electric drive for Hoe printing press, using storage battery for multi-voltage.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous Current Motors for Machine Tools."

### POINT OF CUT-OFF IN A BATTERY DISCHARGE

Carl Hering

Vol. xix—1902, pp. 325-331

Considerations which enter into the determination of proper point of cut-off of discharge for primary and secondary batteries. Graphical solution. Typical discharge curves for constant current, constant resistance and constant power.

*Discussion*, incorporated with that of paper by W. R. Whitney on "Colloids."

### STORAGE-BATTERY INDUSTRIAL LOCOMOTIVES

F. L. Sessions

Vol. xxii—1903, pp. 109-123

General discussion of storage-battery locomotives—their advantages; methods of operating the battery; calculation of battery rating for given service; motor control, etc. Tables for facilitating the calculation of storage-battery rating, with numerical example illustrating their use.

*Discussion*, pp. 124-131, by Messrs. Edgar H. Berry, F. L. Sessions and Elmer A. Sperry.

General remarks on storage-battery performance in industrial locomotive service, and criticisms of author's tables.

### THE STORAGE-BATTERY IN SUBSTATIONS

W. E. Goldsborough and P. E. Fansler

Vol. xxvii—1909, pp. 243-277

Description of Indiana Union Traction Company distribution system. Account and results of tests showing the efficiency of the various parts

of the system, the performance and requirements of storage batteries in sub-stations. Graphic records of battery performance.

*Discussion*, incorporated with that of paper by Clarence Renshaw on "Some Notes on the Operation of Railway Motors in Service."

#### THE COMPARATIVE BEHAVIOR OF FLOATING AND BOOSTER-CONTROLLED BATTERIES ON FLUCTUATING LOADS

Lamar Lyndon

Vol. xxii—1903, 705-731

Analysis of the performance of an electric railway plant with storage battery arranged in the following ways: Floating battery in station; floating battery on line; battery and booster on line; battery on the line and booster in the station. Numerical examples and comparison of the merits of different systems.

*Discussion*, pp. 732-734, by Messrs. J. R. Appleton, J. L. Woodbridge, W. E. Goldsborough, J. W. Lieb, Jr., W. W. Donaldson, A. S. Hubbard, F. L. Flanders and H. Etheridge.

Lead batteries for high discharge rates. E. m. f. characteristic of Edison battery under rapid discharge.

#### ON THE CALCULATION OF LINE BATTERIES

W. E. Winship

Vol. xxiii—1904, pp. 393-402

Outline of method of determining the size and location of battery floating on railway distribution system under various conditions of service.

*Discussion*, pp. 457-459, by Messrs. F. J. White, Lamar Lyndon and W. E. Winship.

Practical importance of battery resistance in calculation of line batteries.

#### APPLICATION OF STORAGE BATTERIES TO REGULATION OF ALTERNATING- CURRENT SYSTEMS

J. L. Woodbridge

Vol. xxvii—1908, pp. 987-1021

Brief general discussion of the various types of service where storage batteries can be used to regulate the alternating-current load, including brief descriptions of some typical plants. Detailed description of the use of storage batteries with carbon regulator, split-pole converter and synchronizing exciter, with analysis of performance. Analysis and oscillograms of e. m. f. waves of three-part and two-part pole converters. A general solution for the e. m. f. wave form of two-part pole converter.

*Discussion* (including paper by Comfort A. Adams on "Voltage Ratio in Synchronous Converters, with Special Reference to the Split-Pole Converter"), pp. 1022-1055, by Messrs. P. M. Lincoln, A. S. Hubbard, W. L. Waters, Chas. P. Steinmetz, J. L. Burnham, J. L. Woodbridge and G. E. Brown.

General discussion of the performance characteristics of the split-pole converter, with physical exposition of the method of varying the voltage ratio and its effect on armature reaction, heating and commutation. Data from tests in commercial operation.



THE APPLICATION OF STORAGE BATTERIES TO THE REGULATION OF THE ALTERNATING-CURRENT LOAD AT THE PLANT OF THE INDIANA STEEL COMPANY, GARY, INDIANA

J. Lester Woodbridge

Vol. xxviii—1909, pp. 851-866

Description, theory and results of batteries used in connection with split-pole converters and synchronous exciters for regulation of alternating-current circuits.

*Discussion*, pp. 867-868, by Messrs. Edward Van Wagenen and J. L. Woodbridge.

Characteristics of synchronous exciter.

## 8. TRANSFORMERS

### THE TRANSFORMER FOR MEASURING LARGE DIRECT CURRENTS

Harris J. Ryan

Vol. xviii—1901, pp. 169-183

Description of the theory of operation, the design and construction of the transformer. Account of tests demonstrating the degree of accuracy under various conditions, such as occur in testing switchboard instruments in place.

*Discussion*, pp. 184-190, by Messrs. Geo. T. Hanchett, Gano S. Dunn, Samuel Sheldon, A. E. Kennelly, C. O. Mailloux and Townsend Wolcott.

Criticism of the method and answers thereto.

### Y AND Δ CONNECTION OF TRANSFORMERS

F. O. Blackwell

Vol. xxii—1903, pp. 385-389

Discussion of relative advantages of star and delta connection of transformers upon the construction of the transformers, the operation of transformers with neutral grounded, and rises of potential in star and T-connected transformers.

*Discussion*, pp. 390-416, by Messrs. J. S. Peck, C. F. Scott, R. F. Hayward, M. H. Gerry, Jr., V. G. Converse, P. N. Nunn, P. H. Thomas, P. M. Lincoln, Peter Junkersfeld, A. L. Mudge, J. E. Woodbridge and Louis Bell.

Comprehensive discussion of maximum possible strains with various single-phase and polyphase transformer connections for single and double transformations with grounded and ungrounded neutral. Dangers that may arise from operation with grounded neutral. Experience in operation of high-tension system with and without grounded neutral.

### THE RELATIVE FIRE-RISK OF OIL AND AIR-BLAST TRANSFORMERS

E. W. Rice, Jr.

Vol. xxiii—1904, pp. 171-173

*Discussion*, pp. 175-197, 236-238 and 246, by Messrs. F. A. C. Perrine, J. S. Peck, Calvert Townley, Ralph D. Mershon, C. E. Skinner, H. G. Stott, P. N. Nunn, P. M. Lincoln, C. L. de Muralt, O. S. Lyford, Jr., Howard Bayne, W. L. Waters, Irving A. Taylor, Norman T. Wilcox, A. C. Pratt, H. A. Lardner, H. F. Parshall, R. S. Kelsch, H. W. Tobey, William J. Hazard, E. P. Roberts, W. S. Moody, James Lyman, W. A. Blanck, P. Junkersfeld, G. N. Eastman, D. W. Roper, G. H. Lukes, W. G. Carlton, and J. W. Farley.

General discussion of the relative fire hazard of air-blast and oil immersed transformers. Combustion and explosive properties of oil. Experience with fires involving oil immersed and air-blast transformers. Methods of installing transformers so as to reduce fire risk to a minimum.

## TERMINALS AND BUSHINGS FOR HIGH-PRESSURE TRANSFORMERS

Walter S. Moody

Vol. xxiii—1904, pp. 225-230

Location, arrangement and insulation of transformer terminals.

*Discussion*, pp. 231-235, by Messrs. Ralph D. Mershon, C. E. Skinner, Irving A. Taylor, N. M. Snyder and A. C. Pratt.

General remarks on transformer terminals and terminal bushings.  
Weak spots in construction of transformer terminals, taps and bushings.  
Bushing treated as a condenser.

## THE USE OF GROUND-SHIELDS IN TRANSFORMERS

J. S. Peck

Vol. xxlii—1904, pp. 553-554

Description of the nature and purpose of the ground shield and list of objections to its use.

*Discussion*, pp. 555-556, by Messrs. Ralph D. Mershon, H. C. Wirt, C. E. Skinner, P. H. Thomas and W. L. Waters.

Objections to ground shield. Advantages of grounded neutral.

## THE CURRENT TRANSFORMER

Kenneth L. Curtis

Vol. xxv—1906, pp. 715-726

Method of predetermining the performance of series transformer from tests of exciting current and internal losses. Method of measuring small inductances.

*Discussion*, pp. 727-734, by Mr. L. T. Robinson.

Testing of series transformer for ratio and phase angle. Oscillograms of exciting current of series transformers.

## RELATIVE MERITS OF THREE-PHASE AND ONE-PHASE TRANSFORMERS

H. W. Tobey

Vol. xxvi—1907, pp. 813-815

Brief general remarks.

*Discussion*, incorporated with paper by John S. Peck on "Relative Advantages of One-Phase and Three-Phase Transformers."

## RELATIVE ADVANTAGES OF ONE-PHASE AND THREE-PHASE TRANSFORMERS

John S. Peck

Vol. xxvi—1907, pp. 817-821

Classification and discussion of relative advantages and disadvantages of three-phase and bank of three single-phase transformers.

*Discussion* (including that of paper by H. W. Tobey on "Relative Merits of Three-Phase and One-Phase Transformers"), pp. 822-834, by Messrs. Peter Junkersfeld, R. F. Schuchardt, C. W. Stone, Walter S. Moody, W. B. Jackson, P. M. Lincoln, Edward A. Wagner, A. H. Pikler, E. N. Lake, H. B. Gear, A. S. McAllister, W. F. Lamme, K. C. Randall and D. L. Huntington.

Experience with three-phase transformers. Relative advantages of shell and core-type three-phase transformers with regard to repairs.

**FORCED-OIL AND FORCED-WATER CIRCULATION FOR COOLING OIL-INSULATED  
TRANSFORMERS**

C. C. Chesney

Vol. xxvi—1907, pp. 835-839

Brief description of forced-oil method of cooling transformers, giving the saving in cost. Diagram of piping connections.

*Discussion*, pp. 837-850, by Messrs. C. W. Stone, W. S. Moody, A. Henry Pikler, W. B. Jackson, P. M. Lincoln, S. M. Kintner, A. H. Babcock, M. C. Canfield, G. Percy Cole, D. L. Huntington, W. F. Lamme, William McClellan, A. L. Mudge and Calvert Townley.

Relative advantages of forced-water and forced-oil cooling. Characteristics of oil as a cooling agent. Illustrated description of forced-oil plant.

**CHOKE-COILS VERSUS EXTRA INSULATION ON THE END-WINDINGS OF  
TRANSFORMERS**

S. M. Kintner

Vol. xxvi—1907, pp. 1169-1172

Brief statement of the purpose of the choke-coil, followed by a list of advantages and disadvantages incident to its use, both inside and outside the transformer case.

*Discussion*, incorporated with paper by H. W. Tobey on "Notes on Transformer Testing."

**PROTECTION OF THE INTERNAL INSULATION OF A STATIC TRANSFORMER AGAINST  
HIGH-FREQUENCY STRAINS**

Walter S. Moody

Vol. xxvi—1907, pp. 1173-1178

Illustrated description of a method of protecting transformers by providing extra insulation on the end turns and bringing out the taps from the center of the winding.

*Discussion*, incorporated with paper by H. W. Tobey on "Notes on Transformer Testing."

**NOTES ON TRANSFORMER TESTING**

H. W. Tobey

Vol. xxvi—1907, pp. 1179-1189

Brief general instructions for testing transformers so as to determine their chief characteristics—ratio, polarity, resistance, copper losses, core losses, exciting current, regulation, insulation, high potential and heating.

*Discussion* (including that of paper by S. M. Kintner on "Choke-Coils Versus Extra Insulation on the End-Windings of Transformers," and paper by Walter S. Moody on "Protection of the Internal Insulation of a Static Transformer Against High-Frequency Strains"), pp. 1190-1208, by Messrs. S. M. Kintner, A. H. Pikler, P. M. Lincoln, J. W. Fraser, W. N. Smith, Charles W. Stone, E. E. F. Creighton, William McClellan, W. S. Lee, R. P. Jackson, Charles P. Steinmetz, Ralph D. Mershon, D. B. Rushmore, W. LeRoy Emmet, O. S. Lyford, Jr., H. W. Buck, W. S. Moody, H. W. Tobey, E. J. Berg, B. C. Shipman, Frank G. Baum, A. C. Pratt, James Lyman and Farley Osgood.

General remarks on the protective value of choke coils, their location and insulation, and on the use of extra insulation on the end turns of transformers, either with or without choke coils.

#### TESTS WITH ARCING GROUNDS AND CONNECTIONS

Ernst J. Berg

Vol. xxvii—1908, pp. 741-751

Account of tests with arcing grounds on transformers with single-phase and polyphase connections to study the effect of such grounds under various conditions and indicate the best methods of protecting transformers.

*Discussion*, incorporated with paper by Percy H. Thomas on "Critical Study of Lightning Records on Taylor's Falls Transmission Line."

#### A TRIGONOMETRIC METHOD FOR THE SOLUTION OF ALTERNATING-CURRENT PROBLEMS

Harold Pender

Vol. xxvii—1908, pp. 1397-1424

Development of a short method for solving alternating-current problems with examples of its application to single-phase and three-phase transmission lines, transformer and induction motors. Tables of reactance capacity, resistance and drop factors for use in such calculations.

*Discussion*, pp. 1424-1427, by Messrs. Comfort A. Adams, W. A. Del Mar and L. W. Rosenthal.

Magnitude of errors involved by this method when applied to transmission line calculations.

#### HIGH-VOLTAGE TRANSFORMERS AND PROTECTIVE AND CONTROLLING APPARATUS FOR OUTDOOR INSTALLATION

K. C. Randall

Vol. xxviii—1909, pp. 189-207

Description of types of apparatus, with estimates of relative costs of outdoor and indoor installations. Operation of outdoor transformer stations.

*Discussion*, incorporated with that of A. B. Reynders' paper on "Condenser Type of Insulation for High-Tension Terminals."

#### CONDENSER TYPE OF INSULATION FOR HIGH-TENSION TERMINALS

A. B. Reynders

Vol. xxviii—1909, pp. 209-220

Theory, construction and tests of special form of high-tension terminal bushing built with alternate layers of metal foil and insulation.

*Discussion*, pp. 221-268, including that of K. C. Randall's paper on "High-Tension Transformers and Protective and Controlling Apparatus for Outdoor Installation," by Messrs. W. S. Moody, Percy H. Thomas, David B. Rushmore, Paul M. Lincoln, E. M. Hewlett, S. Piek, Guido Semenza, A. E. Kennelly, J. S. Peck, Ralph D. Mershon, W. S. Franklin, N. J. Neall, G. Faccioli, C. L. de Mural, V. D. Moody, M. W. Franklin, A. B. Reynders, Ralph W. Pope, F. G. Baum, O. S. Lyford, Jr., Carl

Schwartz, J. B. Whitehead, John J. Frank, W. L. Waters, L. L. Perry, J. N. Kelman, August H. Kruesi, and D. Kos.

General discussion of the advisability of using outdoor transformer and switching stations. Experience with outdoor high-tension apparatus. Theory and calculation of condenser type bushings. Construction of oil and asphalt filled insulating bushings.

#### METHOD OF TESTING TRANSFORMER CORE LOSSES GIVING SINE WAVE RESULTS ON COMMERCIAL CIRCUITS

L. W. Chubb

Vol. xxviii—1909, pp. 417-431

The use, construction and limits of accuracy of a special instrument—iron-loss voltmeter—consisting of a wattmeter connected in series by an exciting winding on a steel core and calibrated to read the impressed voltage of sine wave e. m. f. Also a description of a method of adjusting form factor in core-loss tests.

*Discussion*, pp. 432-438, by Messrs. Frederick Bedell, Charles P. Steinmetz, M. G. Lloyd, L. T. Robinson, Charles F. Scott and L. W. Chubb.

General discussion of the use and limitations of iron-loss voltmeter. Description of a method for obtaining sine wave from a commercial circuit.

#### THE TESTING OF TRANSFORMER STEEL

M. G. Lloyd and J. V. S. Fisher

Vol. xxviii—1909, pp. 439-467

Conditions and requirements of the wattmeter method of core-loss testing, with description of Bureau of Standards modification of Epstein apparatus. Analysis of core losses and results of tests on large variety of transformer steels.

*Discussion*, pp. 468-473, by Messrs. L. T. Robinson, V. Karapetoff, C. E. Skinner, J. C. Lincoln, Clayton H. Sharp, Andrew Pinkerton, E. E. F. Creighton and M. G. Lloyd.

Discussion of the relative value of Bureau of Standards method and the Epstein method for commercial testing. Relation of magnetizing current to transformer regulation.

#### EVEN HARMONICS IN ALTERNATING-CURRENT CIRCUITS

John B. Taylor

Vol. xxviii—1909, pp. 725-732

Description of conditions under which even harmonics may be produced in commercial circuits, with special reference to the effect of stray direct current on the performance of stationary transformers. Tests and oscillograms of transformer exciting current with stray direct current in the windings.

*Discussion*, pp. 733-736, by Messrs. Frederick Bedell, V. Karapetoff, Charles F. Scott, Charles P. Steinmetz and John B. Taylor.

Production of even harmonics in alternators and effect of direct current in the windings of a transformer upon the losses.

CORONA PHENOMENA IN AIR AND OIL AND THEIR RELATION TO  
TRANSFORMER DESIGN

W. S. Moody and G. Faccioli

Vol. xxviii—1909, pp. 769-798

Theoretical and experimental investigation of corona formation in apparatus of limited dimensions in air and in oil, showing the effect of character of surface, insulating masses, conductor masses, dimensions of conductor, etc.

*Discussion*, pp. 799-804, by Messrs. John B. Whitehead, J. C. Lincoln, Ralph D. Mershon, S. B. Charters, Jr., W. S. Moody and Harris J. Ryan.

Dielectric strength and conducting character of air. Mechanical strains due to corona under oil. Description of Ryan's corona voltmeter.

ELECTRICAL MEASUREMENTS ON CIRCUITS REQUIRING CURRENT AND  
POTENTIAL TRANSFORMERS

L. T. Robinson

Vol. xxviii—1909, pp. 1005-1039

Theoretical discussion of the effects of instrument transformers on the accuracy of ammeter and wattmeter measurements, together with tables of correction factors for phase angle error in power measurements. Theory of operation of series transformer showing effects of variation in frequency, secondary impedance, line current, power-factor and wave form. Description of methods of testing series and shunt instrument transformers with ratio and phase-angle performance curves from actual test.

*Discussion*, pp. 1040-1052, by Messrs. C. H. Sharp, M. G. Lloyd, L. W. Chubb, J. Dalemont, Albert F. Ganz and L. T. Robinson.

Methods of measuring ratio and phase angle of current transformers and correction factor for instrument transformers in polyphase measurements.

## SOME PHASES OF TRANSFORMER REGULATION

W. A. Hillebrand and S. B. Charters, Jr.

Vol. xxviii—1909, pp. 1253-1267

Experimental study of effect of phase and voltage unbalance on transformer regulation, using different systems of connection.

*Discussion*, pp. 1268-1278, by Messrs. F. E. Giebel, W. F. Lamme, B. G. Lamme, J. W. White, S. G. Gassaway, C. L. Gory, F. V. T. Lee, H. C. Holberton and W. A. Hillebrand.

General discussion of the effects of voltage unbalance on power apparatus and measuring instruments connected to transformers.

OBSERVATION OF HARMONICS IN CURRENT AND IN VOLTAGE WAVE  
SHAPES OF TRANSFORMERS

John J. Frank

Vol. xxix—1910, pp. 809-890

Experimental investigation and analysis of the wave form of transformer currents and e.m.f. for single-phase and polyphase connections, showing the practical signification of wave distortion in transformer

operation. Methods of wave analysis fully explained and 176 oscillograms shown.

*Discussion*, pp. 891-903, by Messrs. H. J. Ryan, G. Faccioli, W. A. Hillebrand, C. A. Copeland, L. B. Stillwell, C. L. Cory, Silvanus P. Thompson, Edmund C. Stone, C. Fortescue, C. A. Adams and J. J. Frank.

General remarks on the causes and effects of wave distortion in transformers. Analysis of hysteresis loops and additional explanations of the results of Mr. Frank's tests.

#### DISRUPTIVE STRENGTH WITH TRANSIENT VOLTAGES

Joseph L. R. Hayden and Charles P. Steinmetz

Vol. xxix—1910, pp. 1125-1158

Account of experimental investigation of the effects of time and energy on the dielectric strength of air and oil. Full description of the method of testing and analysis of results. Characteristic curves of the dielectric strength of air and oil with different shaped electrodes, showing effect of duration of stress and of the energy behind the stress. Empirical equations.

*Discussion*, incorporated with that of H. W. Tobey's paper on "Dielectric Strength of Oil."

#### DIELECTRIC STRENGTH OF OIL

H. W. Tobey

Vol. xxix—1910, pp. 1189-1207

Description of the properties of insulating oils and methods of testing and handling such oils. Tests showing effects of form of electrode, temperature, and moisture on dielectric strength of oils, with characteristic curves. Analytical and experimental study of methods of drying and filtering oil.

*Discussion*, pp. 1208-1232, including that of paper by Messrs. Joseph L. R. Hayden and Charles P. Steinmetz on "Disruptive Strength with Transient Voltages," and Mr. J. B. Whitehead's paper on "The Electric Strength of Air," by Messrs. D. B. Rushmore, V. Karapetoff, Percy H. Thomas, A. E. Kennelly, W. H. Pratt, E. E. F. Creighton, J. C. Lincoln, Charles F. Scott, Harris J. Ryan, R. D. Mershon, C. P. Steinmetz, John B. Whitehead and M. A. de Chatelain.

General comments on the results of the tests, with various suggested explanations of the phenomena of corona, and relation of diameter of the conductor and other factors to the apparent dielectric strength of air.

#### DETERMINATION OF TRANSFORMER REGULATION UNDER LOAD CONDITIONS AND SOME RESULTING INVESTIGATIONS

Adolph Shane

Vol. xxix—1910, pp. 1281-1294

Description of a method of measuring directly transformer regulation, also a method of direct determination of the transformer impedance triangle. Full account of tests made to establish the accuracy of the methods.



*Discussion*, pp. 1295-1302, by Messrs. Charles Fortescue, E. A. Wagner L. T. Robinson, Ralph W. Atkinson and Adolph Shane.

Objections to the author's methods. Modifications of the author's methods.

**SOME RECENT DEVELOPMENTS IN EXACT ALTERNATING-CURRENT  
MEASUREMENTS**

Clayton H. Sharp and William W. Crawford

Vol. xxix—1910, pp. 1517-1541

Description of design and construction of various precision devices—synchronous reversing key, adjustable mutual inductance, phase shifter and heavy current non-inductive shunt—showing their application in the accurate measurement of ratio and phase angle of series and shunt instrument transformers and in an alternating-current potentiometer.

*Discussion*, pp. 1542-1552, by Messrs. V. Karapetoff, L. T. Robinson, W. H. Pratt, C. P. Steinmetz, Clayton H. Sharp and William W. Crawford.

General remarks on precision measurements of alternating-current quantities. Description of a water-cooled electro-dynamometer, also of a method of measuring very high frequency alternating current.

## 9. ELECTRIC MACHINERY

### A. DIRECT-CURRENT MACHINES

#### NOTES ON MODERN ELECTRIC RAILWAY PRACTICE

Albert H. Armstrong

Vol. xviii—1901, pp. 589-601

Consideration of the requirements of different classes of electric railway service leading up to a discussion of the relative merits of direct-current series and induction motors for interurban and trunk line operation.

*Discussion*, incorporated with that of paper by Ernst J. Berg on "Electric Railway Apparatus."

#### A VARIABLE RELUCTANCE METHOD OF MOTOR SPEED CONTROL

G. Fred Packard

Vol. xix—1902, pp. 1131-1141

Reference to earliest work in this direction. Description of the Johnson method of varying the reluctance at the pole face, while maintaining the commutating fringe. Performance tests and flux distribution curves of a Stow motor built on these principles.

*Discussion*, pp. 1142-1143, by Messrs. Chas. P. Steinmetz, William Esty, G. Fred Packard, P. H. Thomas and E. B. Raymond.

#### THREE-WIRE SYSTEM FOR VARIABLE SPEED MOTOR WORK

N. W. Storer

Vol. xx—1902, pp. 127-133

Description of the operation of adjustable speed motors from three-wire generator, giving advantages of the system and the range of speed variation when combined field and armature control are used.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous Current Motors for Machine Tools."

#### CONTINUOUS-CURRENT MOTORS FOR MACHINE TOOLS

F. O. Blackwell

Vol. xx—1902, pp. 159-165

Power characteristics and requirements of various classes of machine tools. Brief mention of the different methods of speed control of electric motors and the advantages and limitations of each.

*Discussion* (including that of paper by R. T. E. Lozier on "The Operation of Machine Shops by Individual Electric Motors"; paper by N. W. Storer on "Three-Wire System for Variable Speed Motor Work"; paper by H. B. Coho on "The Storage Battery as a Factor in Speed Control"; paper by P. O. Keilholtz on "Electrically Operated Coal Hoist Having Variable Speed Control"; paper by Geo. W. Fowler on "A Series-Parallel System of Speed Control;" and paper by H. Ward Leonard on "Multiple-Unit, Voltage Speed Control for Trunk Line Service"), pp. 166-195, by Messrs. Gano S. Dunn, Chas. F. Scott, H. E. Heath, S. T. Dodd,

Arthur Williams, Philip Lange, Chas. Day, R. T. E. Lozier, N. W. Storer, H. Ward Leonard, Herbert Dowe, H. B. Coho, Geo. A. Damon, R. W. Stovel, Geo. B. Dusingberre, W. A. Dick, P. M. Lincoln, W. L. Campbell, Chas. G. Winslow, E. M. Tingley, ——— Stevenson, ——— Barr, R. H. Pierce, Peter Junkersfeld, O. E. Osthoff, D. C. Jackson, B. J. Arnold, G. B. Foster, Ernest Gonzenbach, V. R. Lansingh, H. H. Cutler, E. J. Pearson and H. R. King.

Relative merits of various methods of speed control of direct-current motors. Conditions which determine the choice between individual and group drive. Effects of motor drive and suitable speed control on shop efficiency. Advantages and disadvantages of the Ward-Leonard system of locomotive driven from single-phase circuits.

#### METHODS OF SPEED CONTROL

Wm. Cooper

Vol. xx—1902, pp. 197-213

Outline of the general power requirements of the different classes of machine tools. Description of method of choosing proper size of motor for given service and speed range from a speed horse-power diagram for combining multiple-voltage and field regulation; numerical examples. Set of general rules for determining motor size.

No discussion.

#### THE FACTORS WHICH AFFECT THE ENERGY LOSSES IN ARMATURE CORES

J. Walter Esterline and C. E. Reid

Vol. xxii—1903, pp. 445-460

Description of apparatus for experimental investigation of armature core losses. Analysis of core losses and results of tests showing effect of teeth, core section, solid poles, laminated poles and other factors of such losses.

*Discussion*, pp. 461-466, by Messrs. J. W. Esterline, Henry Pikler, W. E. Goldsborough, W. S. Franklin, Leonard Wilson, C. O. Mailloux and A. E. Kennelly.

Effect of number of poles and of pole arc upon armature core losses.

#### PRE-DETERMINATION OF SPARKING IN DIRECT-CURRENT MACHINES

W. L. Waters

Vol. xxiii—1904, pp. 365-378

Early methods of designing commutator machines, followed by development of sparking constant for different types of series and shunt-wound machines.

*Discussion*, incorporated with that of paper by E. H. Anderson on "Effect of Self-Induction on Railway Motor Commutation."

#### EFFECT OF SELF-INDUCTION ON RAILWAY MOTOR COMMUTATION

E. H. Anderson

Vol. xxiii—1904, pp. 379-391

Experimental study of commutation with oscillographic records of pressures between commutator segments under various conditions and of

potential rise in field and armature windings due to interruption and restoration of power at free running speeds.

*Discussion* (including that of paper by W. L. Waters on "Predetermination of Sparking in Direct-Current Machines"), pp. 443-457, by Messrs. W. L. Waters, E. R. Douglas, R. B. Treat, Thorburn Reid, E. H. Anderson, W. S. Franklin, Clarence P. Feldman and H. Ward Leonard.

General remarks on commutation reaction and predetermination of the limitation of commutation.

#### LIMITS OF INJURIOUS SPARKING IN DIRECT-CURRENT COMMUTATION

Thorburn Reid

Vol. xxiv—1905, pp. 611-642

Mathematical investigation of destruction of commutator surface based on the theory that all injury results from contact surface energy due to current density and sliding friction. Equations for determining maximum energy density and maximum temperature rise. Derivation of equations given in the appendix.

*Discussion*, pp. 643-648, by Messrs. Gano S. Dunn, Charles P. Steinmetz, W. L. Waters, Thorburn Reid and J. N. Dodd.

General remarks on contact energy theory of damage done by commutation.

#### LIMITATIONS IN DIRECT-CURRENT MACHINE DESIGN

Sebastian Sentius

Vol. xxiv—1905, pp. 689-712

Development of a system of design based upon experimental data and commercial guarantees, with investigation of the limits imposed by commutation difficulties.

*Discussion*, pp. 713-716, by Messrs. Gano S. Dunn, W. L. Waters, Charles P. Steinmetz and Sebastian Sentius.

Actual limits in size of direct-current machines. Factors which modify author's conclusions.

#### DIRECT-CURRENT MOTOR DESIGN AS INFLUENCED BY THE USE OF THE INTERPOLE

C. H. Bedell

Vol. xxv—1906, pp. 329-339

Flux distribution curves taken from interpole motors. Some factors in the design of interpoles and advantages from their use.

*Discussion*, pp. 340-348, by Messrs. H. F. T. Erben, C. H. Bedell, W. L. Waters, N. J. Neall, S. Sentius, S. S. Wheeler, David Hall, L. D. Nordstrum and Chas. P. Steinmetz.

General remarks on the advantages of interpoles on constant and adjustable speed shunt motors, turbo-generators and series railway motors.

#### COMMUTATING-POLE DIRECT-CURRENT RAILWAY MOTORS

E. H. Anderson

Vol. xxvi—1907, pp. 1407-1417

Brief review of troubles encountered in the design of railway motors, leading up to commutation which is treated more in detail. Theory of

action of commutating poles in series motor and possibilities as to voltage and service capacity which it introduces into direct-current railway engineering.

*Discussion*, pp. 1418-1419, by Messrs. Gano Dunn, J. C. Lincoln, E. H. Anderson and W. N. Smith.

Flashing and creeping distances on 600-volt ordinary and 1200-volt commutating pole railway motors.

#### CHARACTERISTICS OF MOTORS FOR LARGE SHEARS

Brent Wiley

Vol. xxvii—1908, pp. 321-334

Discussion of the characteristics of different types of direct-current and alternating-current motors for driving large bloom shears, with actual load curves and full data of the machines tested.

No discussion.

#### CALCULATION OF IRON LOSSES IN DYNAMO ELECTRIC MACHINERY

I. E. Hanssen

Vol. xxviii—1909, pp. 993-1001

Experimental study of stream lines in various types of armatures, with a simple method for predetermining the total iron loss.

*Discussion*, pp. 1002-1004, by Messrs. R. E. Hellmund, A. E. Averett, V. Karapetoff and I. E. Hanssen.

Remarks on the accuracy of the author's method.

#### POLE-FACE LOSSES

C. A. Adams, A. C. Lanier, C. C. Pope and C. O. Schooley

Vol. xxviii—1909, pp. 1133-1156

Theoretical and experimental investigation of pole-face losses, establishing quantitative relations between such losses and the principal variables for both solid and laminated pole shoes. Comparison of calculated losses with test values.

No discussion.

#### ACYCLIC (HOMOPOLAR) DYNAMOS

J. E. Noeggerath

Vol. xxiv—1905, pp. 1-18

Theory of operation of various types of homopolar generators with brief description of the design features, the construction and the performance characteristics of an actual turbo-homopolar generator.

*Discussion*, pp. 19-27, by Messrs. F. B. Crocker, A. E. Kennelly, C. Cartwright, F. V. Henshaw, J. E. Noeggerath, H. E. Heath, W. H. Pratt, G. H. Stickney and C. M. Green.

General remarks on the advantages and limitations of the homopolar generator.

## 9. ELECTRIC MACHINERY

## B. SYNCHRONOUS MACHINES

## ELECTRIC RAILWAY APPARATUS

Ernst J. Berg

Vol. xviii—1901, pp. 603-630

Discussion of the characteristics and limitations of generators, converters, motor-generators and motors for different kinds of electric railway service. Extended consideration of the relative merits of direct-current series, and polyphase induction motors in a given numerical instance, comparing performance, efficiency and cost.

*Discussion* (including that of paper by Albert H. Armstrong on "Notes on Modern Electric Railway Practice"), pp. 631-666, by Messrs. Paul Janet, Chas. P. Steinmetz, G. Gillon, Chas. Janisch, Bion J. Arnold, C. O. Mailloux, E. P. Roberts, L. B. Stillwell, A. H. Pott, C. F. Scott, P. K. Stern, H. C. Spaulding, F. S. Holmes, Ernst J. Berg, A. H. Armstrong and N. C. Sawers.

General remarks on the stability of the induction motor for traction purposes.

## PARALLEL RUNNING OF ALTERNATORS

Ernst J. Berg

Vol. xviii—1901, pp. 753-757

Development of equation covering the principles of parallel operation of alternators, showing the effect of armature reaction, the cause of hunting and remedy.

*Discussion*, incorporated with that of paper by W. I. Slichter on "Angular Velocity in Steam Engine in Relation to Paralleling of Alternators."

A METHOD OF COMPOUNDING ALTERNATING-CURRENT GENERATORS AND MOTORS,  
DIRECT-CURRENT GENERATORS, SYNCHRONOUS MOTOR-GENERATORS  
AND SYNCHRONOUS CONVERTERS

Frank George Baum

Vol. xix—1902, pp. 745-757

Description of original methods of compounding alternating-current generators, synchronous motors, direct-current generators, synchronous converters, synchronous motor generators and transmission systems. Use of the Baum regulation diagram.

*Discussion*, incorporated with that of paper by Chas. P. Steinmetz on "Notes on the Theory of the Synchronous Motor."

## NOTES ON THE THEORY OF THE SYNCHRONOUS MOTOR

Chas. P. Steinmetz

Vol. xix—1902, pp. 781-801

Development of the phase characteristics of the synchronous motor, followed by analytical investigation of electro-mechanical resonance or surging and the conditions which determine the stability of a synchronous motor.

*Discussion* (including that of paper by Frank George Baum on "A Method of Compounding Alternating-Current Generators and Motors, Direct-Current Generators, Synchronous Motor-Generators and Synchronous Converters"; paper by M. LeBlanc on "Formula for Calculating

the Electromotive Force at Any Point of a Transmission Line for Alternating Current"; and paper by H. W. Buck on "The New Generating Plants of the Niagara Falls Power Company"), pp. 802-808 and 1210, by Messrs. F. A. C. Perrine, F. G. Baum, C. A. Adams, H. W. Buck, A. V. Garratt, P. H. Thomas, Chas. P. Steinmetz and B. A. Behrend.

Results of tests with Baum's compensator for compound excitation of alternators, design data for the compensator. General discussion of switchboard arrangement.

**AN EXPERIMENT WITH SINGLE-PHASE ALTERNATORS ON POLYPHASE CIRCUITS**  
C. O. Mailloux

Vol. xix—1902, pp. 851-861

Description of tests made on the lines of the Phoenix Light and Fuel Company, Arizona, to determine the suitability of operating single-phase generator in each phase of a polyphase system, and of producing a polyphase system with single-phase generators, and a synchronous converter as balancer.

*Discussion*, pp. 862-864, by Messrs. C. P. Steinmetz, W. B. Potter, C. O. Mailloux, H. E. Heath and John Murphy.

General remarks on this method of operation. Experience with two-phase converter operated from single-phase generator.

**ENERGY LOSS IN COMMERCIAL INSULATING MATERIALS WHEN SUBJECTED TO HIGH POTENTIAL STRAINS**

Charles Edward Skinner

Vol. xix—1902, pp. 1047-1062

Experimental study of energy losses in dielectrics, showing the effects of variation in voltage, temperature, moisture and frequency. The exact nature of the dielectric not given. Test of energy losses in 5,000-kilowatt engine-type alternator of Manhattan Railway Company.

*Discussion* (including that of paper by Percy H. Thomas on "The Function of Shunt and Series Resistance in Lightning Arresters," and paper by Miles Walker on "Electrostatic Wattmeter in Commercial Measurements"), pp. 1063-1073, by Edw. L. Nichols, Chas. F. Hopewell, Chas. E. Skinner, W. S. Andrews, F. A. C. Perrine, Elihu Thomson, William Maver, Jr., P. B. Woodworth, C. P. Steinmetz and P. H. Thomas.

Observed dielectric strength of mica under oil. Electrolytic conduction in cable insulation. Effect of moisture on dielectric strength of oil. General remarks on lightning arresters.

**THE DETERMINATION OF ALTERNATOR CHARACTERISTICS**

Louis A. Herdt

Vol. xix—1902, pp. 1093-1121

Analytical and experimental study of alternator characteristics with description of different methods for determining regulation. Results of calculations checked with tests on inductor and revolving field types of machines. Diagrams of the magnetic circuits of the machines tested, and many test curves of load and saturation characteristics, flux distribution, etc.

No discussion.

**THE EXPERIMENTAL BASIS FOR THE THEORY OF THE REGULATION  
OF ALTERNATORS**

B. A. Behrend

Vol. xxi—1903, pp. 497-517

Experimental study of regulation of alternators indicating an approximate method of determining the regulation from the combination of the Behn-Eschenburg or e. m. f. method and the Institute or ampere-turn method.

**THE COMPOUNDING OF SELF-EXCITED ALTERNATING-CURRENT GENERATORS  
FOR VARIATION IN LOAD AND POWER-FACTOR**

A. S. Garfield

Vol. xxi—1903, pp. 569-577

Description of the compounding and compensating characteristics of the Latour self-exciting alternator with brushes in different positions on both inductive and non-inductive loads.

*Discussion*, pp. 578-587, by Messrs. C. F. Scott, B. A. Behrend, C. A. Adams, Gano S. Dunn, W. L. Waters, J. R. Armstrong, Marius Latour, P. M. Lincoln, V. Karapetoff, ——— Schmit, J. S. Peck and E. Molin.

General remarks on importance of specifying regulation and on methods of estimating it. Latour method of compounding alternators.

**COMMERCIAL ALTERNATOR DESIGN**

W. L. Waters

Vol. xxii—1903, pp. 39-57

Practical discussion of the economic design of revolving field alternators. Numerical examples used to demonstrate the quantitative effect of various factors that enter into the design. Comparison of the design constants and cost of present-day alternators with those of ten years ago.

*Discussion*, pp. 58-62, by Messrs. W. L. Waters, David B. Rushmore, Ralph D. Mershon, and Harris J. Ryan.

Effects of various degrees of regulation. Desirability of standardizing regulation at zero, instead of unity power-factor.

**THE MECHANICAL CONSTRUCTION OF REVOLVING-FIELD ALTERNATORS**

David B. Rushmore

Vol. xxiii—1904, pp. 253-290

Comprehensive review of the constructive details of modern alternating-current generators. Profusely illustrated with working drawings and sketches covering practically all types of construction.

*Discussion*, incorporated with that of paper by H. M. Hobart and F. Punga on "A Contribution to the Theory of the Regulation of Alternators."

**A CONTRIBUTION TO THE THEORY OF THE REGULATION OF ALTERNATORS**

H. M. Hobart and F. Punga

Vol. xxiii—1904, pp. 291-322

Theoretical investigation of armature reaction in single-phase and poly-phase generator. Development of method of calculating the regulation and excitation from the design constants of the machine. Actual tests of



accuracy of the method in given instances. Complete design data given for the machines tested. Derivation of all new formulas.

*Discussion* (including that of paper by David B. Rushmore on "The Mechanical Construction of Revolving-Field Alternators"), pp. 323-343, by Messrs. C. A. Adams, Jr., B. A. Behrend, W. L. Waters, Gano S. Dunn, David B. Rushmore, F. A. C. Perrine, Bradley T. McCormick, V. Karapetoff, H. M. Hobart and Franklin Punga.

Discussion of analytical and graphical methods of calculating exciting current and regulation from design data and experimental data.

#### OPERATION OF SYNCHRONOUS CONVERTERS

S. C. Lindsay

Vol. xxiii—1904, pp. 345-351

Account of experience with the parallel operation of 60-cycle synchronous converter, where much trouble was experienced from hunting. No discussion.

#### DATA AND TESTS ON A 10,000-CYCLE-PER-SECOND ALTERNATOR

B. G. Lamme

Vol. xxiii—1904, pp. 417-428

Description of construction of machines, covering mechanical and electrical features. Results of tests plotted as curves showing the performance of the machine at different frequencies—saturation curves, iron losses, short-circuit current, friction and windage.

*Discussion*, pp. 459-460, by Mr. F. D. Newbury.

Method of measurements in 10,000-cycle generator tests.

#### SYNCHRONOUS MOTORS FOR REGULATION OF POWER-FACTOR AND LINE PRESSURE

B. G. Lamme

Vol. xxiii—1904, pp. 481-492

Discussion of factors which enter into the design of synchronous motor for power-factor regulation. Application of synchronous motors as regulators and as combined motor and regulator. General remarks on power-factor regulation, use of synchronous converters, cost of synchronous motor regulation, choice of location of regulator, etc.

*Discussion*, pp. 494-510, by Messrs. F. O. Blackwell, W. L. Waters, H. B. Gear, W. B. Jackson, F. A. C. Perrine, Ralph D. Mershon, S. B. Storer, Charles F. Scott, J. S. Peck, H. W. Buck and T. J. Johnston.

General remarks on power-factor and e. m. f. regulation with synchronous motors. Description of methods of automatically adjusting the excitation of the synchronous motor.

#### A SELF-EXCITING ALTERNATOR

E. F. Alexanderson

Vol. xxv—1906, pp. 61-77

Description of a self-exciting compounding alternator which operates with rectifying commutator.

*Discussion*, pp. 78-80, by Messrs. A. E. Kennelly, F. C. Scott, W. L. R. Emmett, A. S. McAllister and E. F. Alexanderson.

# SOME FEATURES AFFECTING THE PARALLEL OPERATION OF SYNCHRONOUS MOTOR-GENERATOR SETS

J. B. Taylor

Vol. xxv—1906, pp. 113-13

Analysis of phenomena causing unequal division of load between synchronous motor-generator sets, with requirements in design, construction and operation necessary to overcome these difficulties. Tests showing magnitude and character of unbalanced conditions. Detailed directions for starting synchronous motor-generator sets.

*Discussion*, pp. 137-138, by Messrs. W. L. Waters and J. B. Taylor.

Experience in parallel operation of synchronous motor-generator sets.

# HEAT TESTS OF ALTERNATORS

Sebastian Sentius

Vol. xxv—1906, pp. 311-325

Analytical discussion of various methods of making heat tests of alternators without facilities for full-load output. Author proposes method that can be used on machines having equal numbers of poles or equal layers of parallel windings.

*Discussion*, pp. 326-327, by Dr. C. P. Steinmetz.

Approximate heat tests of alternators of any type.

# THE SELF-SYNCHRONIZING OF ALTERNATORS

Morgan Brooks and M. K. Akers

Vol. xxv—1906, pp. 453-458

Synchronizing with impedance and reactance coils.

No discussion.

# INTRODUCTION TO DISCUSSION ON THE PRACTICABILITY OF LARGE GENERATORS WOUND FOR 22,000 VOLTS

B. A. Behrend

Vol. xxvi—1907, pp. 351-356

Brief outline of some of the difficulties encountered in the construction of high voltage generators. Performance curves taken from 150-kilowatt, 22,000-volt alternator.

*Discussion*, pp. 357-385, by Messrs. B. A. Behrend, C. E. Skinner, W. S. Murray, A. H. Armstrong, W. L. Waters, Percy H. Thomas, Philip Torchio, F. V. Henshaw, C. F. Scott, Paul M. Lincoln, Ralph D. Mershon, F. G. Baum, Ernst J. Berg, W. J. Foster, R. S. Kelsch, L. Schuler, Farley Osgood, H. F. Parshall, A. Henry Pikler, Bertrand P. Rowe, A. B. Reynders, Guido Semenza and John Pearson.

Advantages and disadvantages of high-voltage generators. Experience with some high-voltage machines. Comparative costs of high and low-voltage alternators.

# INTERACTION OF SYNCHRONOUS MACHINES

Morgan Brooks

Vol. xxvi—1907, pp. 1027-1046

Development of a circle diagram for representing the physical relations and quantities of ideal synchronous machines in parallel operation.

Mathematical analysis of the problem and expressions for the input, output, losses, efficiency and synchronizing power.

*Discussion*, pp. 1047-1048, by Messrs. E. J. Berg, Charles P. Steinmetz and Comfort A. Adams.

Practical limitations of Professor Brook's method. Origin of the circle diagram used in the paper.

#### THE GROUNDED NEUTRAL, WITH AND WITHOUT SERIES RESISTANCE, IN HIGH-TENSION SYSTEMS

Paul M. Lincoln

Vol. xxvi—1907, pp. 1585-1595

General discussion of the advantages and disadvantages of the grounded neutral, followed by brief remarks on the making of grounds and the effect of series resistance in the ground circuit.

*Discussion*, incorporated with paper by George I. Rhodes on "Experience with a Grounded Neutral on the High-Tension System of the Interborough Rapid Transit Company."

#### EXPERIENCE WITH A GROUNDED NEUTRAL ON THE HIGH-TENSION SYSTEM OF THE INTERBOROUGH RAPID TRANSIT COMPANY

George I. Rhodes

Vol. xxvi—1907, pp. 1605-1610

Reasons for installing grounded neutral with series resistor on high-tension cable system. Cross currents between star-connected generators. Relative damage resulting from cable short circuits with and without grounded neutral.

*Discussion* (including that of paper by Paul M. Lincoln on "The Grounded Neutral, with and without Series Resistance, in High-Tension Systems," and that of paper by F. G. Clark on "The Grounded Neutral"), pp. 1611-1641, by Messrs. Peter Junkersfeld, Philip Torchio, N. J. Neall, John B. Taylor, Carl Schwarz, C. W. Stone, F. B. H. Paine, Charles F. Scott, Paul M. Lincoln, George I. Rhodes, Charles P. Steinmetz, Frank G. Baum, and O. S. Lyford, Jr.

Experience with grounded neutral on very large underground cable and overhead transmission systems. Description of device for automatically selecting and disconnecting defective cables.

#### A NEW LARGE GENERATOR FOR NIAGARA FALLS

B. A. Behrend

Vol. xxvii—1908, pp. 1057-1068

Photographs, drawings and brief description of the design and construction of a 10,000-h.p. 300-r.p.m. generator. Brief outline of theory of stresses in rotating disks and rings.

*Discussion*, incorporated with paper by Jens Bache-Wiig on "Application of Fractional Pitch Windings to Alternating-Current Generators."

## MODERN DEVELOPMENT IN SINGLE-PHASE GENERATORS

W. L. Waters

Vol. xxvii—1908, pp. 1069-1076

Brief general discussion of difficulties in the design of large single-phase turbo-generators, due to pulsation of armature reaction and to mechanical stresses on end connections when carrying short-circuit current.

*Discussion*, incorporated with paper by Jens Bache-Wiig on "Application of Fractional Pitch Windings to Alternating-Current Generators."

## APPLICATION OF FRACTIONAL PITCH WINDINGS TO ALTERNATING-CURRENT GENERATORS

Jens Bache-Wiig

Vol. xxvii—1908, pp. 1077-1085

Brief general outline of the advantages of the fractional pitch winding with respect to utilization of copper and space and to facilitation of manufacture, followed by a short discussion of its effect on armature reaction and wave form.

*Discussion* (including paper by B. A. Behrend on "A New Large Generator for Niagara Falls," and paper by W. L. Waters on "Modern Development in Single-Phase Generators"), pp. 1086-1097, by Messrs. Wm. J. Foster, B. A. Behrend, L. Schuler, F. H. Clough, Chas. P. Steinmetz and W. L. Waters.

General remarks on the design of single-phase turbo-alternators and comments on the mechanical design of 10,000-h.p. high-speed generators.

## THE RELATIVE PROPORTIONS OF COPPER AND IRON IN ALTERNATORS

Carl J. Fechheimer

Vol. xxvii—1908, pp. 1429-1458

Analytical study of the costs and weights of materials in alternators, expressing the various factors in the form of equations and solving for minimum cost. Example comparing calculations from equations with calculations from actual dimensions.

*Discussion*, pp. 1457-1458, by Messrs. W. L. Waters and Comfort A. Adams.

## ALTERNATOR FOR 100,000 CYCLES

E. F. W. Alexanderson

Vol. xxviii—1909, pp. 399-415

Description of the mechanical design and electrical characteristics of a high-frequency alternator.

*Discussion*, pp. 413-415, by Messrs. John B. Taylor, J. C. Lincoln, David B. Rushmore, C. J. Fechheimer, and A. E. Kennelly.

Further description of the mechanical and electrical operative characteristics of the 100,000-cycle generator.

## COMPARATIVE COSTS OF 25-CYCLE AND 60-CYCLE ALTERNATORS

Carl J. Fechheimer

Vol. xxviii—1909, pp. 975-989

Theoretical analysis of the cost of material and construction of 25 and 60-cycle alternators of ratings up to 6,500 kw.

*Discussion*, pp. 990-991, by Messrs. J. C. Lincoln, M. G. Lloyd and Carl J. Fechheimer.

Relation between armature copper and field copper and rating of alternators.

#### ELECTROMOTIVE FORCE WAVE SHAPE IN ALTERNATORS

Comfort A. Adams

Vol. xxviii—1909, pp. 1053-1076

Description of a method of calculating wave shape of e. m. f. from flux distribution curve, with tables of correction factors for various types of windings. Examples indicating the relation of winding type to wave shape.

*Discussion*, p. 1077, by Messrs. J. C. Lincoln and Comfort A. Adams.

Choice of pitch to eliminate higher harmonics.

#### PARALLEL OPERATION OF THREE-PHASE GENERATORS, WITH THEIR NEUTRALS INTERCONNECTED

George I. Rhodes

Vol. xxix—1910, pp. 765-790

Analytical development of the relations between the factors that produce neutral currents in star-connected generators with interconnected neutrals, so as to permit a close predetermination of the magnitude of the currents, followed by an application of the equation to existing generators, the results being checked by tests. Remedies for the prevention of these currents are suggested.

*Discussion*, pp. 791-807, by Messrs. H. J. Ryan, S. J. Lisberger, G. I. Rhodes, C. L. Cory, L. B. Stillwell, C. F. Adams, Paul Downing, E. F. Scattergood, W. F. Lamme, P. M. Lincoln, C. A. Adams, S. B. Charters, Jr., W. A. Hillebrand, Ralph D. Mershon, and H. Y. Hall.

Some experience with plants operating with star-connected generators with interconnected neutrals. Laboratory reproduction of these conditions. Feasibility of applying author's remedies.

### C. INDUCTION MACHINES

#### THE INDUCTION MOTOR AND THE ROTARY CONVERTER AND THEIR RELATION TO THE TRANSMISSION SYSTEM

Chas. F. Scott

Vol. xviii—1901, pp. 371-382

Detailed comparison of induction and synchronous motors as to construction, performance characteristics and operation. General discussion of synchronous converters, induction motor-generators and synchronous motor-generators, bringing out their relation to the generator.

*Discussion*, incorporated with that of paper by E. W. Rice, Jr., on "The Control of High-Voltage Systems of Large Power."

#### NOTES ON MODERN ELECTRIC RAILWAY PRACTICE

Albert H. Armstrong

Vol. xviii—1901, pp. 589-601

Consideration of the requirements of different classes of electric railway service leading up to a discussion of the relative merits of direct-

current series and induction motors for interurban and trunk line operation.

*Discussion*, incorporated with that of paper by Ernst J. Berg on "Electric Railway Apparatus."

#### ELECTRIC RAILWAY APPARATUS

Ernst J. Berg

Vol. xviii—1901, pp. 603-630

Discussion of the characteristics and limitations of generators, converters, motor-generators and motors for different kinds of electric railway service. Extended consideration of the relative merits of direct-current series, and polyphase induction motors in a given numerical instance, comparing performance, efficiency and cost.

*Discussion* (including that of paper by Albert H. Armstrong on "Notes on Modern Electric Railway Practice"), pp. 631-666, by Messrs. Paul Janet, Chas. P. Steinmetz, G. Gillon, Chas. Janisch, Bion J. Arnold, C. O. Mailloux, E. P. Roberts, L. B. Stillwell, A. H. Pott, C. F. Scott, P. K. Stern, H. C. Spaulding, F. S. Holmes, Ernst J. Berg, A. H. Armstrong, and N. C. Sawers.

General remarks on the stability of the induction motor for traction purposes.

#### A NOVEL COMBINATION OF POLYPHASE MOTORS FOR TRACTION PURPOSES

Ernst Danielson

Vol. xix—1902, pp. 527-539

Description of a system of concatenating two motors of unequal numbers of poles so as to get four running speeds. Comparison of acceleration characteristics, torque, energy, efficiency, etc., with direct-current series, plain, induction and concatenated induction motors. Abstracted by Dr. Chas. P. Steinmetz on page 495.

*Discussion* (including that of paper by Carl L. DeMuralt on "Some Notes on European Practice in Electric Traction with Three-Phase Alternating Current"), pp. 540-555, by Messrs. C. P. Steinmetz, C. O. Mailloux, Henry G. Stott, W. N. Smith, W. J. Hammer, Townsend Wolcott, Frederick V. Henshaw, and C. L. DeMuralt.

#### THE SINGLE-PHASE INDUCTION MOTOR

William S. Franklin

Vol. xxiii—1904, pp. 429-441

Physical analysis of the performance of the single-phase induction motor, with equations for the principal electrical factors. Application of the Heyland diagram to the single-phase motor.

*Discussion*, pp. 466-469, by Messrs. W. S. Franklin and A. S. McAllister.

Criticisms of Steinmetz's method of dealing with the single-phase induction motor. Test showing effect on exciting current of disconnecting one phase of the two-phase motor.

## THE DESIGN OF INDUCTION MOTORS

Comfort A. Adams

Vol. xxiv—1905, pp. 649-684

Exposition of a method of calculating the leakage factors of an induction motor and expressing the power-factor in terms of design constants and the exciting current in terms of the torque current. Numerical examples of the application of these methods to actual motors.

*Discussion*, pp. 685-687, by Messrs. W. L. Waters, Charles P. Steinmetz and Comfort A. Adams.

Actual degree of accuracy in induction motor construction. Degree of accuracy necessary in design.

## EDDY CURRENTS IN LARGE SLOT-WOUND CONDUCTORS

A. B. Field

Vol. xxiv—1905, pp. 761-788

Theoretical investigation of the I<sup>2</sup>R losses caused by eddy currents in conductors imbedded in slots. Loss constants given for various arrangements with different shaped slots with solid and laminated conductors.

No discussion.

## ALTERNATE-CURRENT MACHINERY-INDUCTION ALTERNATORS

William Stanley Assisted by G. Faccoli

Vol. xxiv—1905, pp. 851-872

Description of induction generators excited with alternating current of frequency differing from that of mechanical rotation. Mode of operation giving theory of e. m. f. regulation, followed by regulation curves from actual tests. Determination of size of exciter and description of type of exciter suitable for obtaining proper e. m. f. characteristics at very low frequencies.

*Discussion*, pp. 873-877, by Messrs. Charles P. Steinmetz, Comfort A. Adams and W. E. Goldsborough.

Explanation of the mode of operation by considering the machine a frequency converter.

## AIR-GAP FLUX IN INDUCTION MOTORS

A. S. Langsdorf

Vol. xxiv—1905, pp. 919-931

Theoretical and mathematical study of the effect upon flux distribution of varying the number of stator teeth, the exciting current assumed to be a sine wave.

*Discussion*, pp. 932-933, by Messrs. B. A. Behrend, Fitzhugh Townsend, A. H. Pikler, and A. S. Langsdorf.

Criticisms of the assumptions made by the author.

## COMPARISON OF TWO AND THREE-PHASE MOTORS

Bradley McCormick

Vol. xxv—1906, pp. 295-306

Comparison of design constants of two induction machines of the same rating and built on equal frames—one two-phase and the other three-phase.

*Discussion*, pp. 307-309, by Messrs. A. S. McAllister, Bradley McCormick, C. P. Steinmetz, and R. E. Hellmund.

Calculation of exciting current from volume of core and air-gap.

#### FRACTIONAL PITCH WINDINGS FOR INDUCTION MOTORS

C. A. Adams, W. K. Cabot and G. A. E. Irving, Jr., Vol. xxvi—1907, pp. 1485-1503

Derivation of formulas for various leakage reactances—slot, tooth tip, coil end and belt, followed by actual tests, the results of which are plotted as curves.

*Discussion*, incorporated with paper by R. E. Hellmund on "Zigzag Leakage of Induction Motors."

#### ZIGZAG LEAKAGE OF INDUCTION MOTORS

R. E. Hellmund Vol. xxvi—1907, pp. 1505-1524

Definitions and derivations of formulas for magnetic leakage coefficients of induction motors, leading up to the formula for light-load zigzag leakage coefficient. General discussion of the subject. Effect of fractional pitch winding on excitation of induction motors.

*Discussion* (including that of paper by C. A. Adams, W. K. Cabot and G. A. E. Irving, Jr., on "Fractional Pitch Windings for Induction Motors"), pp. 1525-1526, by Messrs. J. C. Lincoln, Charles P. Steinmetz, B. T. McCormick, Comfort A. Adams, and A. S. McAllister.

#### THE NON-SYNCHRONOUS GENERATOR IN CENTRAL STATION AND OTHER WORK

W. L. Waters Vol. xxvii—1908, pp. 157-180

General characteristics of induction generator; method of operation; methods of excitation; regulation; behavior on short-circuits; advantages in connection with steam turbine and gas engine drive.

Analytical discussion of its suitability to different kinds of service—large and small central stations and in the production of direct current with steam turbines.

*Discussion*, incorporated in paper by J. E. Woodbridge on "Some Features of Railway Converter Design and Operation."

#### CALCULATION OF THE STARTING TORQUE OF SINGLE-PHASE INDUCTION MOTORS WITH PHASE-SPLITTING STARTING DEVICES

I. E. Hanssen Vol. xxvii—1908, pp. 373-375

No discussion.

#### INDUCTION MOTORS FOR MULTI-SPEED SERVICE, WITH PARTICULAR REFERENCE TO CASCADE OPERATION

H. C. Specht Vol. xxvii—1908, pp. 1177-1195

Analytical and experimental investigation of performance and characteristics of a Cascade set arranged for direct and differential concatenation.



*Discussion*, pp. 1196-1212, by Messrs. W. I. Slichter, A. E. Averett, Elmer A. Sperry, and H. C. Specht.

Relation between effectiveness of concatenation and magnitude of speed range. Description of several compensated Cascade sets.

#### THE HEATING OF INDUCTION MOTORS

A. Miller Gray

Vol. xxviii—1909, pp. 527-553

Theoretical and experimental investigation of heating of induction motors when starting and while running, showing its effect upon design. Data on thermal conductivity, convection and radiation which are of general value in design of electric machinery.

*Discussion*, pp. 554-558, by Mr. David Hoock.

#### A TRIGONOMETRIC METHOD FOR THE SOLUTION OF ALTERNATING-CURRENT PROBLEMS

Harold Pender

Vol. xxvii—1908, pp. 1397-1424

Development of a short method for solving alternating-current problems with examples of its application to single-phase and three-phase transmission lines, transformer and induction motors. Tables of reactance capacity, resistance and drop factors for use in such calculations.

*Discussion*, pp. 1424-1427, by Messrs. Comfort A. Adams, W. A. Del Mar and L. W. Rosenthal.

Magnitude of errors involved by this method when applied to transmission line calculations.

#### REDUCTION IN CAPACITY OF POLYPHASE MOTORS DUE TO UNBALANCING IN VOLTAGE

S. B. Charters, Jr., and W. A. Hillebrand

Vol. xxviii—1909, pp. 559-575

Experimental study of the effect of unbalanced e. m. f. and phase shift on output of induction and synchronous motors.

*Discussion*, pp. 576-586, by Messrs. R. E. Hellmund, A. E. Averett, A. M. Dudley, John C. Parker, Charles P. Steinmetz, Charles F. Scott, H. L. Wallau, S. B. Charters, Jr., I. E. Hanssen, and W. E. Hillebrand.

#### THE CURRENT LOCUS OF THE SINGLE-PHASE INDUCTION MOTOR

A. S. Langsdorf

Vol. xxviii—1909, pp. 587-598

Theoretical discussion of a method of calculating the exact secondary current locus for single-phase induction motors.

*Discussion*, pp. 599-600, by Messrs. V. Karapetoff and A. S. Langsdorf.

Teaching the theory of the single-phase induction motor.

#### MULTI-SPEED INDUCTION MOTORS

H. G. Reist & H. Maxwell

Vol. xxviii—1909, pp. 601-609

Theoretical discussion of methods of varying speeds of induction motors by changing the number of poles, the change of poles being accomplished

by regrouping the coils, by use of independent windings and by concatenation. Actual tests.

*Discussion*, pp. 610-614, by Messrs. H. C. Specht, A. M. Dudley, Charles P. Steinmetz, E. F. W. Alexanderson, A. E. Averett, and H. G. Reist.

General discussion of limitations of these methods of speed variation, and additional data on internal concatenation.

#### FUNCTION OF FLY-WHEELS IN CONNECTION WITH ELECTRICALLY OPERATED ROLLING MILLS

H. C. Specht

Vol. xxviii—1909, pp. 869-878

Theoretical analysis of the performance of induction motor rolling mill drive with varying amounts of fly-wheel effect. Numerical examples chosen to indicate the most economical combination for driving a given plate and rail mill.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

#### THE REQUIREMENTS FOR AN INDUCTION MOTOR FROM THE USER'S POINT OF VIEW

Walter B. Nye

Vol. xxix—1910, pp. 147-149

Brief mention of some of the conditions which must be met in the design of coils, bearings, shafts, pulleys and controllers so as to improve continuity of service and facilitate repairs.

*Discussion* (including that of paper by Mr. Dugald C. Jackson on "The Applicability of Electrical Power to Industrial Establishments;" Mr. Charles T. Main's paper on "Central Stations Versus Isolated Plants for Textile Mills;" Mr. R. S. Hale's paper on "The Supply of Electrical Power for Industrial Establishments from Central Stations," and Mr. G. H. Stickney's paper on "Illumination for Industrial Plants"), pp. 150-182, by Messrs. J. C. Parker, Charles B. Burleigh, Norman T. Wilcox, H. B. Emerson, N. W. Dalton, H. W. Peck, R. D. DeWolf, Albert L. Pearson, H. D. James, C. A. Graves, J. H. Gardiner, and H. D. Jackson.

General discussion of the relative advantages and disadvantages of central stations and private plant energy supply, together with figures and experience from actual practice. Brief description of decentralized system of electrical energy production in which moderate size non-condensing turbo-electric stations supply both electricity and steam to consumers, the stations being interconnected both by the electric and the steam distribution systems.

#### INTERACTION OF FLY-WHEELS AND MOTORS WHEN DRIVING ROLL TRAINS BY INDUCTION MOTORS

F. G. Gasche

Vol. xxix—1910, pp. 1385-1402

General discussion of the application of fly-wheels to roll mill drive, followed by mathematical analysis of the forces acting in an induction motor fly-wheel set when coupled to a roll train, with a full mathematical development of the equations.

## D. ALTERNATING-CURRENT COMMUTATOR MACHINES 59

*Discussion*, pp. 1403-1414, by Messrs. C. P. Steinmetz, C. F. Scott, Gano Dunn, Selby Haar, W. W. Crawford, and F. G. Gasche.

Short-cut methods of calculating the performance of fly-wheel induction motor drive for roll trains.

## D. ALTERNATING-CURRENT COMMUTATOR MACHINES

### A STUDY OF THE HEYLAND MACHINE AS MOTOR AND GENERATOR

Comfort A. Adams

Vol. xxi—1903, pp. 519-568

Outline of development of alternating-current commutator motor leading up to the Heyland machine. Principle and theory of operation of the Heyland motor. Tests of the performance characteristics of the machine as a motor, and as shunt and compound generator. Bibliography.

### SPEED-TORQUE CHARACTERISTICS OF THE SINGLE-PHASE REPULSION MOTOR

Walter I. Slichter

Vol. xxiii—1904, pp. 1-7

Observed and calculated performance characteristics of single-phase repulsion motor for railway service compared with direct-current series motor.

*Discussion*, incorporated with that of paper by Charles P. Steinmetz on "The Alternating-Current Railway Motor."

### THE ALTERNATING-CURRENT RAILWAY MOTOR

Charles P. Steinmetz

Vol. xxiii—1904, pp. 9-25

Brief account of early work with compensated series commutator single-phase motor. Design data given for motors built by Eickemeyer and actual performance characteristics of this motor compared with calculated performance of repulsion motor. Analytical theory of single-phase repulsion motor.

*Discussion* (including that of paper by Walter I. Slichter on "Speed-Torque Characteristics of the Single-Phase Repulsion Motor"), pp. 26-81, by Messrs. B. G. Lamme, A. S. McAllister, B. J. Arnold, Charles P. Steinmetz, P. M. Lincoln, W. I. Slichter, Ralph D. Mershon, A. H. Armstrong, Robert Lundell, O. S. Lyford, Jr., H. A. Wagner, Charles F. Scott, B. A. Behrend, W. S. Franklin, Dugald C. Jackson, and V. Karapetoff.

Theory of operation of compensated series and repulsion motors treated analytically and graphically. Observed performance characteristics of repulsion motor as motor and generator.

### REPULSION INDUCTION MOTOR

Maurice Milch

Vol. xxv—1906, pp. 269-290

Theory and performance characteristics of a commutator single-phase induction motor that starts as a repulsion motor.

*Discussion*, pp. 291-294, by Messrs. C. P. Steinmetz, D. C. Jackson and G. Percy Cole.

Some requirements of cotton mill drive.

## 9. ELECTRIC MACHINERY

## THE SINGLE-PHASE COMMUTATOR TYPE MOTOR

B. G. Lamme

Vol. xxvii—1908, pp. 137-156

Brief discussion of certain features in the design of compensated single-phase series motors for railway service; covering effects of magnetic induction and frequency in commutation and torque; decrease of effective air gap; effect of power-factor on overload torque, etc.

No discussion.

THE VECTOR DIAGRAM OF THE COMPENSATED SINGLE-PHASE  
ALTERNATING-CURRENT MOTOR

W. I. Slichter

Vol. xxvi—1907, pp. 1527-1532

Physical theory and development of the diagram.

*Discussion*, p. 1533, by Mr. V. Karapetoff.

Effect of saturation on vector diagram.

## A SINGLE-PHASE RAILWAY MOTOR

E. F. Alexanderson

Vol. xxvii—1908, pp. 1-17

Classification of single-phase railway motors, followed by theoretical analysis of the performance characteristic of a series-repulsion motor.

*Discussion*, pp. 18-42, by Messrs. L. B. Stillwell, B. G. Lamme, W. B. Potter, O. S. Lyford, Jr., W. I. Slichter, S. N. Kintner, Charles P. Steinmetz, W. S. Murray, E. F. Alexanderson, and Elmer A. Sperry.

General remarks on the relative merits of series-repulsion and compensated series motors, with considerable data on the actual performance of the compensated series motor as to power-factor, commutation, brush wear, etc.

A SKETCH OF THE THEORY OF THE ADJUSTABLE SPEED SINGLE-PHASE  
SHUNT INDUCTION MOTOR

F. Creedy

Vol. xxviii—1909, pp. 475-516

Theoretical discussion of methods of varying the speed of single-phase shunt repulsion motors, with results of tests.

*Discussion*, incorporated with that of paper by E. F. W. Alexanderson on "Repulsion Motor with Variable Speed Shunt Characteristics."

## REPULSION MOTOR WITH VARIABLE SPEED SHUNT CHARACTERISTICS

E. F. W. Alexanderson

Vol. xxviii—1909, pp. 511-521

Theoretical discussion of method of speed control for a single-phase shunt repulsion motor.

*Discussion*, pp. 522-526, including discussion of F. Creedy's paper on "Adjustable Speed Single-Phase Shunt Induction Motors," by Messrs. V. Karapetoff, E. F. W. Alexanderson and F. Creedy.

Further remarks on the methods of speed variation of shunt repulsion motors, together with test data.

## ON THE SPACE ECONOMY OF THE SINGLE-PHASE SERIES MOTOR

William S. Franklin and Stanley S. Seyfert

Vol. xxix—1910, pp. 23-40

Theory and tests of a balanced choke coil arrangement for preventing excessive short-circuit currents due to pulsating flux; also description of a proposed single-phase commutator motor with external armature and commutator intended to give improved utilization of space.

*Discussion*, pp. 41-53, by Messrs. S. M. Kintner, E. H. Anderson, E. F. W. Alexanderson, S. S. Seyfert, L. B. Stillwell, and W. S. Franklin.

Detailed criticism of the external armature type motor tending to show its impracticability. Brief mention of other methods of improving space economy. Weight and space factors from actual practice.

## E. CONVERTERS AND MOTOR-GENERATORS

## THE INDUCTION MOTOR AND THE ROTARY CONVERTER AND THEIR RELATION TO THE TRANSMISSION SYSTEM

Chas. F. Scott

Vol. xviii—1901, pp. 371-382

Detailed comparison of induction and synchronous motors as to construction, performance characteristics and operation. General discussion of synchronous converters, induction motor-generators and synchronous motor-generators, bringing out their relation to the generator.

*Discussion*, incorporated with that of paper by E. W. Rice, Jr., on "The Control of High-Voltage Systems of Large Power."

## ELECTRIC RAILWAY APPARATUS

Ernst J. Berg

Vol. xviii—1901, pp. 603-630

Discussion of the characteristics and limitations of generators, converters, motor-generators and motors for different kinds of electric railway service. Extended consideration of the relative merits of direct-current series, and polyphase induction motors in a given numerical instance, comparing performance, efficiency and cost.

*Discussion* (including that of paper by Albert H. Armstrong on "Notes on Modern Electric Railway Practice"), pp. 631-666, by Messrs. Paul Janet, Chas. P. Steinmetz, G. Gillon, Chas. Janisch, Bion J. Arnold, C. O. Mailloux, E. P. Roberts, L. B. Stillwell, A. H. Pott, C. F. Scott, P. K. Stern, H. C. Spaulding, F. S. Holmes, Ernst J. Berg, A. H. Armstrong, and N. C. Sawers.

General remarks on the stability of the induction motor for traction purposes.

## ENERGY TRANSFORMATIONS IN THE SYNCHRONOUS CONVERTER

William S. Franklin

Vol. xxii—1903, pp. 17-33

Analysis of the energy relations in synchronous converters to determine the amount of energy which is conductively transferred from one circuit to the other, and the amount which is transferred inductively. Brief discussion of armature reaction.

*Discussion*, pp. 34-37, by Samuel Sheldon.

Criticism of Prof. Franklin's method.

## CONSTANT-CURRENT MERCURY ARC RECTIFIER

Charles P. Steinmetz

Vol. xxiv—1905, pp. 371-393

Description of mercury arc rectifier system covering operative characteristics, performance tests with various kinds of load, and theory and calculation of the electrical constants.

*Discussion*, pp. 394-396, by Messrs. J. W. Lieb, Jr., John W. Howell, Percy H. Thomas, F. A. C. Perrine, E. F. Northrup, and Charles P. Steinmetz.

Criticism of rectification theory based on properties of arc. First description of rectification with mercury arc. Type of instruments suitable for measurement of rectified currents.

## SYNCHRONOUS CONVERTERS AND MOTOR-GENERATORS

W. L. Waters

Vol. xxiv—1905, pp. 717-732

Comparative speeds, costs and efficiencies of synchronous converters for different voltages and ratings at 25 and 60 cycles. Discussion of operative characteristics of synchronous converters—e. m. f. control, commutation, armature reaction, heating, mounting and mechanical design.

*Discussion*, pp. 733-740, by Messrs. Gano S. Dunn, F. G. Proutt, Charles P. Steinmetz, L. C. Marburg, H. G. Stott, Morgan Brooks, J. W. Lieb, Jr., and W. L. Waters.

Advantages of induction motor in motor-generator sets. Effect of high armature reaction on surging. Operation of synchronous converters in parallel and their behavior under short circuit.

## SHUNT AND COMPOUND-WOUND SYNCHRONOUS CONVERTERS FOR RAILWAY WORK

W. L. Waters

Vol. xxv—1906, pp. 549-553

Some advantages and disadvantages of compound wound synchronous converters.

*Discussion*, pp. 554-557, by Messrs. J. B. Taylor, P. M. Lincoln and W. L. Waters.

General remarks pro and con compound wound synchronous converters.

## MOTOR GENERATORS VS. SYNCHRONOUS CONVERTERS

P. M. Lincoln

Vol. xxvi—1907, pp. 303-311

Brief general analysis of the relative merits of synchronous converters, synchronous motor generator and induction motor generator from operative and economical standpoints.

*Discussion*, pp. 312-349, by Messrs. A. H. Armstrong, W. L. Waters, H. G. Stott, Ralph D. Mershon, Charles W. Stone, Charles F. Scott, Philip Torchio, B. A. Behrend, J. R. C. Armstrong, A. H. Babcock, F. G. Baum, Ernst J. Berg, R. G. Black, Edward P. Burch, H. W. Buck, O. B. Coldwell, W. R. C. Corson, Henry Floy, Clarence E. Gifford, William B. Jackson, R. S. Kelsch, Farley Osgood, John C. Parker, H. F. Parshall, A. C. Pratt, Leo Schuler, Carl Schwartz, Guido Semenza, B. C. Shipman, Miles Walker, and J. B. Whitehead.

General discussion of the relative merits of the synchronous converter, the synchronous motor generator and the induction motor generator with regard to reliability, voltage regulation, efficiency, cost, etc.

## SOME DEVELOPMENTS IN SYNCHRONOUS CONVERTERS

Chas. W. Stone

Vol. xxvii—1908, pp. 181-189

Description of some mechanical details of the vertical type synchronous converter. Brief discussion of the advantages and disadvantages of different methods of voltage regulation including the booster and the split-pole methods.

*Discussion*, incorporated with paper by J. E. Woodbridge on "Some Features of Railway Converter Design and Operation."

## SOME FEATURES OF SYNCHRONOUS CONVERTER DESIGN AND OPERATION

J. E. Woodbridge

Vol. xxvii—1908, pp. 191-216

Analytical study of the three-phase and the six-phase synchronous converter, with a demonstration of the advantages of the self-starting converters and a discussion of the theory and practice of compounding.

*Discussion* (including paper by W. L. Waters on "The Non-Synchronous Generator in Central Station and Other Work," and paper by Chas. W. Stone on "Some Developments in Synchronous Converters"), pp. 217-254, by Messrs. C. F. Scott, Paul M. Lincoln, F. G. Clark, Chas. P. Steinmetz, Comfort A. Adams, J. R. Bibbins, Philip Torchio, J. B. Taylor, W. L. Waters, J. E. Woodbridge, and C. W. Stone.

General discussion of the advantages and disadvantages of the induction generator from the operating standpoint. Split-pole vs. alternating-current booster methods of e. m. f. regulation for converters.

## VOLTAGE RATIO IN SYNCHRONOUS CONVERTERS WITH SPECIAL REFERENCE TO THE SPLIT-POLE CONVERTER

Comfort A. Adams

Vol. xxvii—1908, pp. 959-985

Determination of e. m. f. wave-form from the harmonic analysis of the flux distribution curve. The method is fully developed and then applied to two and three-part pole converters.

*Discussion*, incorporated with paper by J. L. Woodbridge on "Application of Storage Batteries to Regulation of Alternating-Current Systems."

## INTERPOLES IN SYNCHRONOUS CONVERTERS

B. G. Lamme and F. D. Newbury

Vol. xxix—1910, pp. 1625-1653

Analytical discussion of commutation in direct-current generators and synchronous converters, with reference to the advantages and disadvantages of commutating poles. General summary of the factors that limit the economical output of various types of converters.

*Discussion*, pp. 1654-1678, by Messrs. Gano Dunn, H. F. T. Erben, C. P. Steinmetz, Jens Bache-Wiig, P. M. Lincoln, J. L. Burnham, C. W. Stone, C. A. Adams, and B. G. Lamme.

General remarks on the use of commutating poles in synchronous converters, with special reference to interurban service where load factor is very low. Additional data on the design and limiting factors in synchronous converter construction.



## 10. STEAM BOILERS AND PRIME MOVERS

### ANGULAR VARIATION IN STEAM ENGINES

P. O. Keilholtz

Vol. xviii—1901, pp. 703-740

Mathematical investigation of the turning moments due to steam and to inertia of the reciprocating parts, developing method of determining the relation between balancing effect of fly-wheel and the deviation from the position of absolutely uniform speed. Description of method of measuring any velocity variations by means of electrically driven tuning fork with detailed results of tests on a tandem compound engine.

*Discussion*, incorporated with that of paper by Walter I. Slichter on "Angular Velocity in Steam Engines in Relation to Paralleling of Alternators."

### PARALLEL OPERATION OF ENGINE-DRIVEN ALTERNATORS

W. L. R. Emmet

Vol. xviii—1901, pp. 745-751

Account of the development of an anti-surfing device for application to engine governors to enable parallel operation of alternators under all conditions of load.

*Discussion*, incorporated with that of paper by Walter I. Slichter on "Angular Velocity in Steam Engines in Relation to Paralleling of Alternators."

### ANGULAR VELOCITY IN STEAM ENGINES IN RELATION TO PARALLELING OF ALTERNATORS

Walter I. Slichter

Vol. xviii—1901, pp. 759-771

Analytical discussion of causes and effects of irregular crank effort. Actual analysis of performance of engine of given design.

*Discussion* (included with that of paper by P. O. Keilholtz on "Angular Variations in Steam Engines," paper by Chas. P. Steinmetz on "Speed Regulation of Prime Movers and Parallel Operation of Alternators," paper by W. L. R. Emmett on "Parallel Operation of Engine Driven Alternators," and paper by Ernst J. Berg on "Parallel Running of Alternators"), pp. 772-800, by Messrs. R. H. Rice, Jas. A. Seymour, C. F. Scott, R. D. Mershon, W. L. R. Emmet, B. A. Behrend, and August H. Kruesi.

General remarks on requirements of parallel operation of alternators and cause and remedy for hunting. Relation between regulation characteristics of engine and division of load. Methods of measuring angular deviation.

### ECONOMICAL AND SAFE LIMITS IN THE SIZE OF CENTRAL STATIONS

H. A. Lardner

Vol. xxi—1903, pp. 407-416

Brief discussion of the factors that bear upon the relative economy of one large and several small stations. Probable effect of steam turbines

on size of generator units. Actual figures as to most economical size of steam engine. Classified advantages and disadvantages of large central stations.

*Discussion*, incorporated with that of paper by Peter Junkersfeld on "Multiple Versus Independent Operation of Units and Central Stations."

#### GAS POWER FOR CENTRAL STATIONS

J. R. Bibbins

Vol. xxii—1903, pp. 767-790

Analysis of the performance of a number of gas engine stations, covering the operation characteristics, the economy and cost of operation and maintenance. Discussion of the advantages of operating a gas-electric station in connection with gas works, with estimated revenues and cost of operation and maintenance. Much data in tabular form and in form of characteristic curves.

*Discussion*, pp. 791-797, by Messrs. Ralph D. Mershon, Philip Torchio, Herbert A. Wagner, H. G. Stott, and J. R. Bibbins.

Fixed charges of gas-electric and steam-electric plants. Amount of jacket water required by gas engines under different conditions. Relative importance of labor and maintenance with gas and steam engines.

#### NOTES ON FLY-WHEELS

H. H. Barnes, Jr.

Vol. xxiii—1904, pp. 353-363

Analytical study of relation of fly-wheel effect to hunting, giving directions for predetermining the natural frequency of oscillation of a given system.

*Discussion*, pp. 461-466, by Messrs. H. H. Barnes, Jr., W. S. Franklin, Clarence P. Feldman, and H. Y. Hall, Jr.

General remarks on hunting of water-turbine, gas-engine and steam-engine driven machines.

#### POWER PLANT ECONOMICS

Henry G. Stott

Vol. xxv—1906, pp. 1-27

Complete analysis of the losses involved in the transformation of heat energy from coal into electrical energy, the data being taken from one year's record in the power plant of the Interborough Rapid Transit Company. Characteristics and maintenance and operation charges for various prime movers—steam engines, steam turbines, steam engines and exhaust turbines, gas engines, gas engines and steam turbines. Methods of operation suggested whereby best plant economy could be improved.

*Discussion*, pp. 28-60, by Messrs. E. W. Rice, Jr., Chas. E. Lucke, C. C. Chappelle, W. L. R. Emmett, F. E. Junge, Calvert Townley, Hartley LeH. Smith, Paul M. Lincoln, W. E. Moore, Rudolph Wintzer, and J. R. Bibbins.

General discussion of the characteristics, economy and cost of operation of various prime movers, with special reference to low pressure turbines and gas engines. Notes on gas engine practice in Europe. Effect of load factor on cost of electric energy.

## AUTOMATIC SAFETY DEVICES FOR STEAM ENGINES, TURBINES AND MOTORS

Chas. M. Heminway

Vol. xxv—1906, pp. 635-641

Types and applications of automatic engine stops, value of the protection and methods of maintenance of devices in proper condition.

No discussion.

## GAS ENGINE REGULATION FOR DIRECT-CONNECTED UNITS

Charles E. Lucke

Vol. xxvi—1907, pp. 1-24

General discussion of speed regulation problems, defining the function of governors, fly-wheels and valve gears, and listing the variables that enter into the problem. The use of crank-pin force and speed diagrams, in the solution of such problems, is suggested and its application to steam turbine operation used as an illustration. A number of papers before the A. I. E. E. and A. S. M. E. on this subject are abstracted and commented upon.

No discussion.

THE RATIO OF HEATING SURFACE TO GRATE SURFACE AS A FACTOR IN  
POWER PLANT DESIGN

Walter S. Finlay, Jr.

Vol. xxvi—1907, pp. 1709-1719

Account of results obtained in the power plant of the Interborough Rapid Transit Company by installing a second grate under the existing boilers. Analytical study of the economy and saving produced thereby, with graphical performance diagrams and tabular comparison of the cost of maintenance and operation of the single and double grate plants.

*Discussion*, pp. 1720-1737, by Messrs. Charles E. Lucke, W. F. Wells, Walter T. Ray, Henry Keisinger, W. L. Abbott, A. Bement, F. V. Henshaw, W. S. Finlay, Albert A. Cary, J. P. Sparrow, and J. E. Moulthrop.

General remarks on boiler efficiency, with results of experimental investigation and tests on methods of improving efficiency. Actual figures on grate surface, heating surface, rate of combustion, efficiency, etc.

## AN EXHAUST STEAM TURBINE PLANT

Henry H. Wait

Vol. xxvi—1907, pp. 1739-1863

Results of tests on low-pressure turbines with different vacua and steam pressures at the plant of the Wisconsin Steel Company, Chicago.

*Discussion*, pp. 1764-1769, by Messrs. Francis Hodgkinson and J. R. Bibbins.

Characteristics and tests of low-pressure turbine performance.

## DOUBLE-DECK STEAM TURBINE POWER PLANTS

J. R. Bibbins

Vol. xxvii—1908, pp. 1099-1118

General discussion of the advantages of the double-deck turbine station, based on a description of three actual plants, giving space, weights, foundation design, cost and other interesting features.

*Discussion*, pp. 1119-1121, by Messrs. C. W. Ricker and J. R. Bibbins.

Actual itemized cost of West Point double-deck turbine station.

## WORKING RESULTS—GAS-ELECTRIC POWER PLANTS

J. R. Bibbins

Vol. xxvii—1908, pp. 1123-1134

Account of thirty-day test of producer-gas engine plant, with analysis of results indicating the commercial efficiency and the cost of energy at different load-factors. Comparison of costs with steam-turbine station practice.

*Discussion*, pp. 1135-1137, by Messrs. J. P. Jackson and J. R. Bibbins.  
Reliability and overload capacity of gas engines.

## FUEL—THE PURCHASE OF, ON A BRITISH THERMAL UNIT BASIS

Lawrence P. Crecoilius

Vol. xxviii—1909, pp. 51-62

Details of a fuel contract on heat unit basis and discussion of sampling and testing.

No discussion.

## PRIME MOVERS

Charles P. Steinmetz

Vol. xxviii—1909, pp. 63-84

Theoretical discussion of ideal economics of electrical energy production. Characteristics and limitations of various types of prime movers.

*Discussion*, pp. 85-99, by Messrs. Louis A. Ferguson, Charles E. Lucke, Henry E. Longwell, David B. Rushmore, Calvert Townley, and Ernst J. Berg.

Sharp criticisms of the paper. Factors to be considered in choosing prime movers. Numerical examples showing relative cost of energy production by water power and steam.

## NOTES ON THE COST OF POWER

H. G. Stott

Vol. xxviii—1909, pp. 1479-1502

Graphical charts showing results of calculations on the cost of energy as effected by load, load factor and load curve, with different types of prime movers—reciprocating engines, steam turbines, reciprocating engine and exhaust turbine, gas engine and steam turbine, and hydraulic turbines.

No discussion.

## TESTS OF A 15,000-KW. STEAM-ENGINE-TURBINE UNIT

H. G. Stott and R. J. S. Pigott

Vol. xxix—1910, pp. 183-229

Description of the combined high-pressure reciprocating engine and low-pressure turbo-induction generator plant of the Interborough Rapid Transit Company, together with reasons for adopting this type of apparatus and summary of results accomplished by its use. Results and principal data of tests covering economy and performance of the prime movers are presented in tabular and diagrammatic form.

*Discussion*, pp. 230-248, by Messrs. W. L. R. Emmet, Max Rotter, E. F. Miller, Edward L. Clark, E. D. Dreyfus, Charles P. Steinmetz, J. W. Lieb, Jr., D. S. Jacobus, ——— Schaubert, G. R. Parker, O. Junggren, F. Samuelson, R. J. S. Pigott, and H. G. Stott.

**THE GENERATING SYSTEM OF AN ELECTRIC LIGHTING COMPANY****A. R. Cheyney****Vol. xxix—1910, pp. 339-360**

General discussion of important economic features in the operation of large central station plants, showing how economy, efficiency and reliability are maintained in every state of the process from the coal mine to the outgoing feeders of the sub-station

No discussion.

**GAS ENGINES IN CITY RAILWAY AND LIGHTING SERVICE****E. D. Latta, Jr.****Vol. xxix—1910, pp. 429-461**

Description of the gas engine plant of the Charlotte Electric Railway Company, followed by a detailed explanation of the mode of operation of the engines and the producers, together with actual performance record as to shut-downs, speed regulation, parallel running, cost of operation, maintenance and repairs. The theory of producer gas manufacture and combustion.

*Discussion*, pp. 462-464, by Messrs. H. K. English, F. D. Gatchell, and E. D. Latta, Jr.

Additional data on piston-rod packing and the slow oxidation of coal.

**TESTING STEAM TURBINES AND STEAM TURBO-GENERATORS****E. D. Dickinson and L. T. Robinson****Vol. xxix—1910, pp. 1679-1688**

Brief description of methods of testing turbo-generator units, pointing out the precaution that must be exercised in order to attain a high degree of accuracy.

*Discussion*, pp. 1689-1707, by Messrs. Gano Dunn, W. L. R. Emmet, Francis Hodgkinson, W. L. Robb, Edwin D. Dreyfus, W. C. L. Eglin, A. Henry Pikler, E. W. Yearsley, E. B. Rosa, L. T. Robinson, I. E. Moulthrop, and E. D. Dickinson.

General remarks on turbine and turbo-generator testing correction factors, methods of test, accuracy of different measurements, etc.

## 11. POWER PLANTS

### A. BUILDINGS

#### CEMENT IN CENTRAL STATION DESIGN

Eugene B. Clark

Vol. xxiv—1905, pp. 55-63

Description of the construction and installation of concrete floors, roofs, switch cells, conduits, etc.

No discussion.

### B. ECONOMICS

#### ECONOMICAL AND SAFE LIMITS IN THE SIZE OF CENTRAL STATIONS

H. A. Lardner

Vol. xxi—1903, pp. 407-416

Brief discussion of the factors that bear upon the relative economy of one large and several small stations. Probable effect of steam turbines on size of generator units. Actual figures as to most economical size of steam engine. Classified advantages and disadvantages of large central stations.

*Discussion*, incorporated with that of paper by Peter Junkersfeld on "Multiple Versus Independent Operation of Units and Central Stations."

#### CENTRAL STATION ECONOMIES

W. E. Goldsborough and P. E. Fansler

Vol. xxii—1903, pp. 467-499

Description of power plant of the Indiana Union Traction Company and methods used in testing the equipment. Detailed discussion of tests, giving losses in the different parts of the system and the efficiency of the different steps in the transmission from the coal pile to the cars.

*Discussion*, pp. 500-505, by Messrs. W. E. Goldsborough, M. H. Gerry, Jr., H. G. Stott, Gano S. Dunn, W. F. Wells, and P. M. Lincoln.

Ultimate object in the design of a power plant.

#### GAS POWER FOR CENTRAL STATIONS

J. R. Bibbins

Vol. xxii—1903, pp. 767-790

Analysis of the performance of a number of gas engine stations, covering the operation characteristics, the economy and cost of operation and maintenance. Discussion of the advantages of operating a gas-electric station in connection with gas works, with estimated revenues and cost of operation and maintenance. Much data in tabular form and in form of characteristic curves.

*Discussion*, pp. 791-797, by Messrs. Ralph D. Mershon, Philip Torchio, Herbert A. Wagner, H. G. Stott, and J. R. Bibbins.

Fixed charges of gas-electric and steam-electric plants. Amount of jacket water required by gas engines under different conditions. Relative importance of labor and maintenance with gas and steam engines.

## DUPLICATION OF ELECTRICAL APPARATUS TO SECURE RELIABILITY OF SERVICE

H. W. Buck

Vol. xxiv—1905, pp. 261-268

Brief detailed discussion of the conditions which govern the economic usefulness of reserve apparatus in different divisions of a power plant system.

*Discussion* (including that of paper by George F. Chellis on "Time-Limit Relays"), pp. 269-282, by Messrs. H. G. Stott, Philip Torchio, C. O. Mailloux, S. D. Sprong, W. F. Wells, G. F. Chellis, H. W. Buck, H. R. Stuart, P. M. Lincoln, and Charles F. Scott.

General remarks on and experience with time-limit relays. Description of the relay practice of The New York Edison Company. Practice of large company in maintaining continuity of service.

## POWER PLANT ECONOMICS

Henry G. Stott

Vol. xxv—1906, pp. 1-27

Complete analysis of the losses involved in the transformation of heat energy from coal into electrical energy, the data being taken from one year's record in the power plant of the Interborough Rapid Transit Company. Characteristics and maintenance and operation charges for various prime movers—steam engines, steam turbines, steam engines and exhaust turbines, gas engines and steam turbines. Methods of operation suggested whereby best plant economy could be improved.

*Discussion*, pp. 28-60, by Messrs. E. W. Rice, Jr., Chas. E. Lucke, C. O. Chappelle, W. L. R. Emmett, F. E. Junge, Calvert Townley, Hartley LeH. Smith; Paul M. Lincoln, W. E. Moore, Rudolph Wintzer, and J. R. Bibbins.

General discussion of the characteristics, economy and cost of operation of various prime movers, with special reference to low pressure turbines and gas engines. Notes on gas engine practice in Europe. Effect of load factor on cost of electric energy.

THE RELATION OF LOAD FACTOR TO THE EVALUATION OF  
HYDROELECTRIC PLANTS

S. B. Storer

Vol. xxv—1906, pp. 139-143

Brief theoretical study of effect of load factor on cost of electric energy production in steam and water power plants.

No discussion.

AN ANALYSIS OF THE DISTRIBUTION LOSSES IN A LARGE CENTRAL  
STATION SYSTEM

L. L. Elden

Vol. xxvi—1907, pp. 665-680

Record of four years' study of the losses in a certain large energy distribution system, with an account of methods employed to reduce losses between switchboard and consumer.

No discussion.

**THE RATIO OF HEATING SURFACE TO GRATE SURFACE AS A FACTOR IN  
POWER PLANT DESIGN**

Walter S. Finlay, Jr.

Vol. xxvi—1907, pp. 1709-1719

Account of results obtained in the power plant of the Interborough Rapid Transit Company by installing a second grate under the existing boilers. Analytical study of the economy and saving produced thereby, with graphical performance diagrams and tabular comparison of the cost of maintenance and operation of the single and double grate plants.

*Discussion*, pp. 1720-1737, by Messrs. Charles E. Lucke, W. F. Wells, Walter T. Ray, Henry Keisinger, W. L. Abbott, A. Bement, F. V. Henshaw, W. S. Finlay, Albert A. Cary, J. P. Sparrow, and J. E. Moulthrop.

General remarks on boiler efficiency, with results of experimental investigation and tests on methods of improving efficiency. Actual figures on grate surface, heating surface, rate of combustion, efficiency, etc.

**PRIME MOVERS**

Charles P. Steinmetz

Vol. xxviii—1909, pp. 63-84

Theoretical discussion of ideal economics of electrical energy production. Characteristics and limitations of various types of prime movers.

*Discussion*, pp. 85-99, by Messrs. Louis A. Ferguson, Charles E. Lucke, Henry E. Longwell, David B. Rushmore, Calvert Townley, and Ernst J. Berg.

Sharp criticisms of the paper. Factors to be considered in choosing prime movers. Numerical examples showing relative cost of energy production by water power and steam.

**CENTRALIZATION OF POWER SUPPLY**

Presidential Address

Louis A. Ferguson

Vol. xxviii—1909, pp. 355-361

Financial, technical and industrial advantages of centralization of electrical energy production.

No discussion.

**COMMENTS ON THE OPERATION AND DEVELOPMENT OF HYDROELECTRIC PLANTS**

Henry L. Doherty

Vol. xxviii—1909, pp. 1361-1379

General discussion of certain features in the operation and development of hydroelectric plants with a view to improving the standing and value of water-power securities.

*Discussion*, pp. 1380-1478, by Messrs. L. B. Stillwell, Henry G. Stott, S. E. Doane, Cary T. Hutchinson, H. W. Buck, W. N. Ryerson, Calvert Townley, Julian C. Smith, Henry L. Doherty, Carl Schwartz, C. P. Fowler, J. Lester Woodbridge, W. E. Winship, Francis Blossom, Philip P. Barton, C. H. Baker, H. F. Parshall, J. F. Vaughan, E. C. Brown, J. H. Wilson, James Lyman, R. A. Ross, M. H. Collbohm, H. A. Storrs, E. P. Roberts, P. W. Sothman, O. S. Lyford, Jr., D. S. Jacobus, Ralph



D. Mershon, David B. Rushmore, John Martin, Irving E. Brooke, and W. G. Chace.

A very full discussion of hydroelectric economics, with special reference to the following topics: Fixed and operating charges for energy production in hydroelectric plant with steam reserve for different ratios of water power to steam and for different load curves; numerous estimates of first cost of hydroelectric and steam plants and also of plant depreciation; Various data for actual practice of reliability and continuity of service for electric transmission plants; Preliminary data and factors which enter into the valuation of water-power development; Government control.

#### NOTES ON THE COST OF POWER

H. G. Stott

Vol. xxviii—1909, pp. 1479-1502

Graphical charts showing results of calculations on the cost of energy as affected by load, load factor and load curve, with different types of prime movers—reciprocating engines, steam turbines, reciprocating engine and exhaust turbine, gas engine and steam turbine, and hydraulic turbines.

No discussion.

#### THE APPLICABILITY OF ELECTRICAL POWER TO INDUSTRIAL ESTABLISHMENTS

Dugald C. Jackson

Vol. xxix—1910, pp. 107-114

General outline of the advantages of electric power in manufacturing plants, touching upon the cost of producing energy in steam plants and pointing out the advantages of centralizing energy production of factories in same locality.

*Discussion*, incorporated with that of Mr. Walter B. Nye's paper on "The Requirements for an Induction Motor from the User's Point of View."

#### CENTRAL STATIONS VERSUS ISOLATED PLANTS FOR TEXTILE MILLS

Charles T. Main

Vol. xxxix—1910, pp. 115-127

Analytical discussion of the cost of energy for operating textile mills under various conditions, with special reference to advantages and disadvantages of central station service.

*Discussion*, incorporated with that of Mr. Walter B. Nye's paper on "The Requirements for an Induction Motor from the User's Point of View."

#### THE SUPPLY OF ELECTRICAL POWER FOR INDUSTRIAL ESTABLISHMENTS FROM CENTRAL STATIONS

R. S. Hale

Vol. xxxix—1910, pp. 129-137

General discussion of the relative cost of energy production in a central station and in isolated manufacturing plants, with special reference to items usually overlooked in making such estimates.

*Discussion*, incorporated with that of Mr. Walter B. Nye's paper on "The Requirements for an Induction Motor from the Users' Point of View."

## THE GENERATING SYSTEM OF AN ELECTRIC LIGHTING COMPANY

A. R. Cheyney

Vol. xxix—1910, pp. 339-360

General discussion of important economic features in the operation of large central station plants, showing how economy, efficiency and reliability are maintained in every state of the process from the coal mine to the outgoing feeders of the sub-station.

No discussion.

## DIVERSITY FACTOR

H. B. Gear

Vol. xxix—1910, pp. 375-384

Analytical discussion of diversity factor between various elements of the distribution system and of various classes of business, showing its effect on initial investment and cost of service.

No discussion.

## C. HYDROELECTRIC PLANTS

## THE ELECTRIC TRANSMISSION OF POWER FROM NIAGARA FALLS

Lewis B. Stillwell

Vol. xviii—1901, pp. 445-531

Historical outline of the development, design, construction and operation of the electrical equipment of the Niagara Falls power plant. Description of the generators, their design and their performance under tests and in operation. Also a description of the transmission and distribution system, its construction and difficulties encountered in its operation.

*Discussion*, pp. 532-544, by Messrs. L. B. Stillwell, Chas. P. Steinmetz, H. W. Buck, P. M. Lincoln, E. A. Sperry, F. A. C. Perrine, P. K. Stern, H. G. Stott, and Clarence E. Gifford.

General discussion of the methods of operation for large transmission and distribution systems with reference to interruptions from various causes. Experience with grounded wire on long lines in the West. Difficulties in operation of railway converter sub-stations in Buffalo.

## THE NEW GENERATING PLANTS OF THE NIAGARA FALLS POWER COMPANY

H. W. Buck

Vol. xix—1902, pp. 765-780

Brief description of the No. 2 American power house and of the Canadian power house, giving general data concerning the equipment, the wiring and the switchboards.

*Discussion*, incorporated with that of paper by Chas. P. Steinmetz on "Notes on the Theory of the Synchronous Motor."

## AN EFFICIENT HIGH-PRESSURE WATER-POWER TRANSMISSION PLANT

George J. Henry, Jr., and Joseph N. Le Conte

Vol. xxii—1903, pp. 627-645

General description of Pelton wheels and hydraulic equipment for 1923-ft. head. Methods of making performance tests, the results of tests being given in tables and curves.

*Discussion*, pp. 646-647, by Messrs. F. O. Blackwell and H. A. Lardner. First three-phase transmission plant in United States. Pipe lines for high pressure.

## WATER POWERS OF THE SOUTH EASTERN APPALACHIAN REGION.

Frederick A. C. Perrine

Vol. xxiv—1905, pp. 789-800

Brief comparison of the general characteristics of the Appalachian system with other great mountain ranges of the United States. Short résumé of the different water sheds in the South Appalachian system, giving area, rainfall, run-off characteristics, etc.

*Discussion*, pp. 801-806, by Messrs. Ralph W. Pope, C. E. Waddell, L. S. Randolph, A. M. Schoen, F. A. C. Perrine, Carl Hering, J. W. Lieb, Jr., and Gano S. Dunn.

General remarks on hydroelectric power development. Relation between rainfall, distribution and uniformity of run-off. Motion carried to appoint a water power conservation committee.

## THE DEVELOPMENT OF THE ONTARIO POWER COMPANY.

P. N. Nunn

Vol. xxiv—1905, pp. 807-833

Description of the layout and construction of the generating and distribution plants, profusely illustrated with photographs and working drawings.

*Discussion*, pp. 834-838, by Messrs. Gano S. Dunn, W. E. Goldsborough, H. G. Stott, P. H. Thomas, C. A. Greenidge, P. N. Nunn, and Philip P. Barton.

Probable effect of taking water at Chicago upon the flow at Niagara Falls. Characteristics of ice formation in the Niagara River and cause of ice difficulties experienced by Niagara Falls Power Company.

## THE RELATION OF LOAD-FACTOR TO THE EVALUATION OF HYDROELECTRIC PLANTS

S. B. Storer

Vol. xxv—1906 pp. 139-143

Brief theoretical study of effect of load-factor on cost of electric energy production in steam and water-power plants.

No discussion.

## NOTES ON DESIGN OF HYDROELECTRIC POWER STATIONS

David B. Rushmore

Vol. xxv—1906 pp. 145-163

General remarks on some of the factors which enter into the design of a hydroelectric plant. Determination of the magnitude of a given development, choice of wheel and generator rating, of speed, and of efficiency with respect to economy of operation. Data on hydraulic system taken from Reclamation Service.

No discussion.

## A NEW METHOD OF TURBINE CONTROL

Lamar Lyndon

Vol. xxv—1906 pp. 165-177

Theory and description of a water wheel governor designed to compensate pressure rises in pipe systems and to prevent overrunning.

*Discussion*, pp. 178-179, by Messrs. Paul Spencer, Lamar Lyndon, and Carl Hering.

## ELECTRIC POWER TRANSMISSION

Frederick Darlington

Vol. xxv—1906 pp. 181-190

General classification of natural water powers and loads which may be carried by such powers. Outline of data that must be determined in developing water power. Preliminary data and detailed estimates of cost of energy production in a certain plant in the Southern Appalachian mountains; also estimated cost of steam competition.

No discussion.

## ECONOMIES TO BE DERIVED FROM THE UTILIZATION OF WATER POWERS OF LOW HEAD IN THE CENTRAL WEST

Dugald C. Jackson

Vol. xxv—1906, pp. 585-600

Description of development of three water powers by the Janesville Electric Company in Janesville, Wis.

No discussion.

## NOTES ON HYDROELECTRIC PLANT ORGANIZATION AND OPERATION

Farley Osgood

Vol. xxvi—1907, pp. 179-199

Brief general outline of the points to be covered in the development and equipment of a hydroelectric plant, followed by a collection of actual experiences in the operation of a modern plant.

No discussion.

## COMMENTS ON THE OPERATION AND DEVELOPMENT OF HYDROELECTRIC PLANTS

Henry L. Doherty

Vol. xxviii—1909, pp. 1361-1379

General discussion of certain features in operation and development of hydroelectric plants with a view to improve the standing and value of water-power securities.

*Discussion*, pp. 1380-1478, by Messrs. L. B. Stillwell, Henry G. Stott, S. E. Doane, Cary T. Hutchinson, H. W. Buck, W. N. Ryerson, Calvert Townley, Julian C. Smith, Henry L. Doherty, Carl Schwartz, C. P. Fowler, J. Lester Woodbridge, W. E. Winship, Francis Blossom, Philip P. Barton, C. H. Baker, H. F. Parshall, J. F. Vaughan, E. C. Brown, J. H. Wilson, James Lyman, R. A. Ross, M. H. Collbohm, H. A. Storrs, E. P. Roberts, P. W. Sothman, O. S. Lyford, Jr., D. S. Jacobus, Ralph D. Mershon, David B. Rushmore, John Martin, Irving E. Brooke, and W. G. Chace.

A very full discussion of hydroelectric economics, with special reference to the following topics: Fixed and operating charges for energy production in hydroelectric plant with steam reserve for different ratios of water power to steam and for different load curves; Numerous estimates of first cost of hydroelectric and steam plants and also of plant depreciation; Various data for actual practice of reliability and continuity of service for electric transmission plants; Preliminary data and factors which enter into the valuation of water-power development; Government control.

## EMERGENCY GENERATING STATIONS FOR SERVICE IN CONNECTION WITH HYDRO-ELECTRIC TRANSMISSION PLANTS UNDER PACIFIC COAST CONDITIONS

A. M. Hunt

Vol. xxix—1910, pp. 675-684

Analytical study of the comparative merits of a gas engine and a steam turbine station for standby service, covering first costs, standby charges and continuous operation cost. The steam plant is kept in readiness to start by storing electrically generated heat in water under high pressure.

*Discussion*, pp. 685-704, by Messrs. L. B. Stillwell, L. Jorgensen, K. G. Dunn, C. L. Cory, L. L. Johnston, A. H. Babcock, W. A. Doble, F. G. Baum, A. M. Hunt, Cary T. Hutchinson, and P. H. Thomas.

General remarks on standby service in connection with hydroelectric plants, comparing conditions in the West with those in the East and considering the relative value of gas engine, steam and water-power so well built as to require no standby service.

## HYDROELECTRIC POWER AS APPLIED TO IRRIGATION

John Coffee Hays

Vol. xxix—1910, pp. 731-753

Description of a large ground water system of irrigation (Mount Whiting Power Company in California) operated with hydroelectric energy, covering the power equipment; forms of contracts and charges; load characteristics; power requirements for different classes of work, and effect of irrigation on land values.

*Discussion*, pp. 754-764, by Messrs. L. B. Stillwell, E. W. Paul, J. C. Hays, F. V. Henshaw, H. Homberger, L. Jorgensen, Ralph W. Pope, Markham Cheever, A. J. Bowie, Jr., W. A. Doble, and F. G. Baum.

General discussion of the relative advantages of construction having limited life and construction which is practically permanent, also general remarks on irrigation.

## D. STEAM AND GAS-ELECTRIC PLANTS

## TENDENCIES OF CENTRAL STATION DEVELOPMENT

Vol. xxi—1903, pp. 403-405

Introduction by President Chas. F. Scott.

## ECONOMICAL AND SAFE LIMITS IN THE SIZE OF CENTRAL STATIONS

H. A. Lardner

Vol. xxi—1903 pp. 407-416

Brief discussion of the factors that bear upon the relative economy of one large and several small stations. Probable effect of steam turbines on size of generator units. Actual figures as to most economical size of steam engine. Classified advantages and disadvantages of large central stations.

*Discussion*, incorporated with that of paper by Peter Junkersfeld on "Multiple Versus Independent Operation of Units and Central Stations."

**MULTIPLE VERSUS INDEPENDENT OPERATION OF UNITS AND CENTRAL STATIONS**  
 Peter Junkersfeld Vol. xxi—1903 pp. 425-440

General discussion of troubles encountered in the operation of a central station system, covering the different links between the coal pile and the consumer's circuits. Layout for sectional operation of large central station and advantages of this method of operation.

*Discussion* (including that of paper by H. A. Lardner on "Economical and Safe Limits in the Size of Central Stations," and paper by Philip Torchio on "Safety Devices in Central Stations and Sub-stations"), pp. 441-477, by Messrs. C. F. Scott, H. G. Stott, H. A. Wagner, F. A. Waldron, E. H. Sniffen, J. W. Lieb, Jr., Townsend Wolcott, W. S. Rugg, W. L. Abbott, P. Junkersfeld, H. A. Lardner, Philip Torchio, Philip K. Stern, B. J. Arnold, H. B. Gear, W. G. Carlton, Carl Schwartz, F. Hodgkinson, H. Etheridge, C. W. Rice, P. M. Lincoln, Franz Welz, W. C. L. Eglin, Horatio A. Foster, Carl Hering, Chas. Hewitt, and Paul Spencer.

General remarks on central station operation—Fuel handling, prime movers, distribution system, etc., bearing upon the relative merits of a single interconnected system and several independent systems. Economy tests of steam turbines and discussion of the advantages of this type of prime mover. Utility of storage batteries in the operation of continuous-current central station system.

**CENTRAL STATION ECONOMIES**

W. E. Goldsborough and P. E. Fansler

Vol. xxii—1903 pp. 467-499

Description of power plant of the Indiana Union Traction Company and methods used in testing the equipment. Detailed discussion of tests, giving losses in the different parts of the system and the efficiency of the different steps in the transmission from the coal pile to the cars.

*Discussion*, pp. 500-505, by Messrs. W. E. Goldsborough, M. H. Gerry, Jr., H. G. Stott, Gano S. Dunn, W. F. Wells, and P. M. Lincoln.

Ultimate object in the design of a power plant.

**GAS POWER FOR CENTRAL STATIONS**

J. R. Bibbins

Vol. xxii—1903 pp. 767-790

Analysis of the performance of a number of gas engine stations, covering the operation characteristics, the economy and cost of operation and maintenance. Discussion of the advantages of operating a gas-electric station in connection with gas works, with estimated revenues and cost of operation and maintenance. Much data in tabular form and in form of characteristic curves.

*Discussion*, pp. 791-797, by Messrs. Ralph D. Mershon, Philip Torchio, Herbert A. Wagner, H. G. Stott, and J. R. Bibbins.

Fixed charges of gas-electric and steam-electric plants. Amount of jacket water required by gas engines under different conditions. Relative importance of labor and maintenance with gas and steam engines.

MODERN CENTRAL STATION DESIGN AS EXEMPLIFIED BY THE NEW  
TURBO-GENERATOR STATION OF THE EDISON ELECTRIC  
ILLUMINATING COMPANY OF BOSTON

I. E. Moulthrop

Vol. xxiv—1905 pp. 29-43

Description of principal features in the design of the power station with drawings of the station, wiring diagram and layout of switchboard.

*Discussion*, pp. 44-53, by Messrs. J. W. Lieb, Jr., H. G. Stott, F. C. Bates, Philip Torchio, J. H. Hallberg, C. O. Mailloux, W. F. White, I. E. Moulthrop, and P. Junkersfeld.

Central station and financial statistics. Relative merits and costs of surface and barometric condensers. General remarks on central station design.

THE RATIO OF HEATING SURFACE TO GRATE SURFACE AS A FACTOR  
IN POWER PLANT DESIGN

Walter S. Finlay, Jr.

Vol. xxvi—1907 pp. 1709-1719

Account of results obtained in the power plant of the Interborough Rapid Transit Company by installing a second grate under the existing boilers. Analytical study of the economy and saving produced thereby, with graphical performance diagrams and tabular comparison of the cost of maintenance and operation of the single and double grate plants.

*Discussion*, pp. 1720-1737, by Messrs. Charles E. Lucke, W. F. Wells, Walter T. Ray, Henry Keisinger, W. L. Abbott, A. Bement, F. V. Henshaw, W. S. Finlay, Albert A. Cary, J. P. Sparrow, and J. E. Moulthrop.

General remarks on boiler efficiency, with results of experimental investigation and tests on methods of improving efficiency. Actual figures on grate surface, heating surface, rate of combustion, efficiency, etc.

A NEW CO<sub>2</sub> RECORDER

C. O. Mailloux

Vol. xxvi—1907, pp. 1771-1787

Description of Orsat apparatus followed by detailed description of the Westover recorder.

*Discussion*, p. 1788, by A. A. Adler.

DOUBLE-DECK STEAM TURBINE POWER PLANTS

J. R. Bibbins

Vol. xxvii—1908, pp. 1099-1118

General discussion of the advantages of the double-deck turbine station, based on a description of three actual plants, giving space, weights, foundation design, cost and other interesting features.

*Discussion*, pp. 1119-1121, by Messrs. C. W. Ricker and J. R. Bibbins.

Actual itemized cost of West Point double-deck turbine station.

WORKING RESULTS, GAS-ELECTRIC POWER PLANTS

J. R. Bibbins

Vol. xxvii—1908, pp. 1123-1134

Account of thirty-day test of producer-gas engine plant, with analysis of results indicating the commercial efficiency and the cost of energy at

## II. POWER PLANTS

different load factors. Comparison of costs with steam-turbine station practice.

*Discussion*, pp. 1135-1137, by Messrs. J. P. Jackson and J. R. Bibbins. Reliability and overload capacity of gas engines.

**THE PURCHASE OF FUEL ON A BRITISH THERMAL UNIT BASIS**

Lawrence P. Crecelius

Vol. xxviii—1909, pp. 51-62

Details of a fuel contract on heat unit basis and discussion of sampling and testing.

No discussion.

**TESTS OF A 15,000-KW. STEAM-ENGINE-TURBINE UNIT**

H. G. Stott and R. J. S. Pigott

Vol. xxix—1910, pp. 183-229

Description of the combined high-pressure reciprocating engine and low-pressure turbo-induction generator plant of the Interborough Rapid Transit Company, together with reasons for adopting this type of apparatus and summary of results accomplished by its use. Results and principal data of tests covering economy and performance of the prime movers presented in tabular and diagrammatic form.

*Discussion*, pp. 230-248, by Messrs. W. L. R. Emmet, Max Rotter, E. F. Miller, Edward L. Clark, E. D. Dreyfus, Charles P. Steinmetz, J. W. Lieb, Jr., D. S. Jacobus, — Schaubert, G. R. Parker, O. Junggren, F. Samuelson, R. J. S. Pigott, and H. G. Stott.

**E. ELECTRIC STATION APPARATUS AND WIRING**

**THE CONTROL OF HIGH-POTENTIAL SYSTEMS OF LARGE POWER**

E. W. Rice, Jr.

Vol. xviii—1901, pp. 407-420

Description of the type H oil switches designed for Metropolitan Traction Company and Manhattan Railway Company plants, together with short account of performance of oil, air and expulsion tube type switches under tests at high tension. General discussion of principles which should govern the layout of a central station.

*Discussion* (including that of paper by William S. Aldrich and George W. Redfield on "Performance of an Artificial Forty-Mile Transmission Line;" paper by F. A. C. Perrine on "Elements of Design, Particularly Pertaining to Long Distance Transmission;" paper by Charles F. Scott on "The Induction Motor and the Rotary Converter, and Their Relation to the Transmission System," and paper by Chas. P. Steinmetz on "Theoretical Investigation of Some Oscillations of Extremely High Potential in Alternating-Current High-Potential Transmissions"), pp. 421-442 and 667-669, by Messrs. Gano S. Dunn, Geo. D. Shepardson, Henry W. Fisher, W. L. R. Emmett, A. E. Kennelly, Chas. P. Steinmetz, F. A. C. Perrine, L. B. Stillwell, Oberlin Smith, R. D. Mershon, Paul Janet, W. S. Aldrich, C. F. Scott, and Percy H. Thomas.



Relative advantages and comparative performance of induction motors and synchronous motors. Atmospheric losses at high-tension lines as affected by diameter and stranding of conductor. Equation of rise of potential due to opening a circuit.

#### OIL SWITCHES FOR HIGH PRESSURES

E. M. Hewlett

Vol. xxiii—1904, pp. 215-216

Comparison of oil break with air break switches.

*Discussion*, pp. 217-224, 242-245 and 249-251, by Messrs. C. C. Chesney, F. A. C. Perrine, Alex Dow, Ralph D. Mershon, C. F. Scott, P. N. Nunn, C. L. de Muralt, H. F. Parshall, W. A. Blanck, James Lyman, P. Junkersfeld, W. G. Carlton, E. O. Sessions, G. N. Eastman, I. E. Brooke, P. H. Thomas, R. F. Schuchardt, Edw. Schildhauer, H. F. Sanville, W. C. L. Eglin.

Experience with oil switches in many large plants. Accounts of tests under short circuit conditions. Specifications for oil switches and brief reference to some of the mechanical difficulties encountered with present types.

#### DUPLICATION OF ELECTRICAL APPARATUS TO SECURE RELIABILITY OF SERVICE

H. W. Buck

Vol. xxiv—1905, pp. 261-268

Brief detailed discussion of the conditions which govern the economic usefulness of reserve apparatus in different divisions of a power plant system.

*Discussion* (including that of paper by George F. Chellis on "Time-Limit Relays"), pp. 269-282, by Messrs. H. G. Stott, Philip Torchio, C. O. Mailloux, S. D. Sprong, W. F. Wells, G. F. Chellis, H. W. Buck, H. R. Stuart, P. M. Lincoln, and Charles F. Scott.

General remarks on and experience with time-limit relays. Description of the relay practice of The New York Edison Company. Practice of large company in maintaining continuity of service.

#### ELECTRICAL CONNECTIONS FOR POWER STATIONS

David B. Rushmore

Vol. xxv—1906, pp. 559-584

General discussion of the choice and arrangement of station apparatus. Classification of switches, relays and modes of connecting generator and station equipment to the lines.

No discussion.

#### ENCLOSED STATION WIRING

F. O. Blackwell

Vol. xxvi—1907, 851-856

Photographs of high-potential arcs. General rules for wiring high-tension stations.

*Discussion*, pp. 857-871, by Messrs. C. W. Stone, L. C. Marburg, P. M. Lincoln, E. N. Lake, J. D. Jamieson, Fay Woodmansee, P. B. Woodworth,

W. B. Jackson, Dugald C. Jackson, Edwin W. Olds, Bertrand P. Rowe, Stephen Q. Hayes, C. W. Hutton; William McClellan, and L. A. Herdt.

General discussion of the interior high-tension wiring, with special reference to the advisability of enclosing the conductors in fireproof compartments.

#### SWITCHBOARD PRACTICE FOR VOLTAGES OF 60,000 AND UPWARDS

Stephen Q. Hayes

Vol. xxvi—1907, pp. 1333-1357

Brief general discussion of factors which enter into the choice and arrangement of control apparatus in high-tension plants, with special reference to oil switches and circuit breakers. Designs for 60,000 and 100,000-volt stations given to demonstrate the relative space required.

*Discussion*, pp. 1358-1362, by Messrs. P. M. Lincoln, F. B. H. Paine, D. B. Rushmore, H. W. Buck, J. B. Taylor, William McClellan, W. N. Smith, L. C. Nicholson, S. Q. Hayes, J. H. Finney, F. G. Baum, and Ralph D. Mershon.

Use of extra line wire for emergency service. Method of tying conductors to pin type insulators.

#### THE NON-SYNCHRONOUS GENERATOR IN CENTRAL STATION AND OTHER WORK

W. L. Waters

Vol. xxvii—1908, pp. 157-180

General characteristics of induction generator; method of operation; methods of excitation; regulation; behavior on short circuits; advantages in connection with steam turbine and gas engine drive.

Analytical discussion of its suitability to different kinds of service—large and small central stations and in the production of direct-current with steam turbines.

*Discussion*, incorporated in paper by J. E. Woodbridge on "Some Features of Railway Converter Design and Operation."

#### PARALLEL OPERATION OF HYDROELECTRIC PLANTS

W. S. Lee

Vol. xxix—1910, pp. 547-557

General discussion of some of the economic advantages of operating hydroelectric plants in parallel, with all plants tied into one large high-tension distribution system, based on experience with plants of the Southern Power Company located on the southern slopes of the Appalachian Mountains.

*Discussion*, pp. 558-571, by Messrs. W. S. Lee, Charles E. Waddell, Percy H. Thomas, David B. Rushmore, A. M. Schoen, Carl Hering, H. N. Muller, W. L. Waters, Charles F. Scott, and Edward W. Shedd.

General discussion of the parallel operation of hydro-electric plants, with special reference to the use of induction generators and the regulation of speed and e. m. f.

## PARALLEL OPERATION OF THREE-PHASE GENERATORS, WITH THEIR NEUTRALS INTERCONNECTED

George I. Rhodes

Vol. xxix—1910, pp. 765-790

Analytical development of the relations between the factors that produce neutral currents in star-connected generators with interconnected neutrals, so as to permit a close predetermination of the magnitude of the currents, followed by an application of the equation to existing generators, the results being checked by tests. Remedies for the prevention of these currents are suggested.

*Discussion*, pp. 791-807, by Messrs. H. J. Ryan, S. J. Lisberger, G. I. Rhodes, C. L. Cory, L. B. Stillwell, C. F. Adams, Paul Downing, E. F. Scattergood, W. F. Lamme, P. M. Lincoln, C. A. Adams, S. B. Charters, Jr., W. A. Hillebrand, Ralph D. Mershon, and H. Y. Hall.

Some experience with plants operating with star-connected generators with interconnected neutrals. Laboratory reproduction of these conditions. Feasibility of applying author's remedies.

## THE MODERN OIL SWITCH WITH SPECIAL REFERENCE TO SYSTEMS OF MODERATE VOLTAGE AND LARGE AMPERE CAPACITY

A. R. Cheyney

Vol. xxix—1910, pp. 1091-1108

Analytical discussion of the present status of oil switch construction, pointing out lines along which future progress is apt to take place. Record of performance of 90 oil switches in actual service.

*Discussion*, pp. 1109-1124, by Messrs. Peter Junkersfeld, Ford W. Harris, C. W. Stone, D. B. Rushmore, C. P. Steinmetz, W. I. Donshea, V. Karapetoff, G. F. Sever, A. R. Cheyney, and E. M. Hewlett.

General remarks on design and operation of oil switches. Experience in operation and results of experimental study.

## INTERPOLES IN SYNCHRONOUS CONVERTERS

B. G. Lamme and F. D. Newbury

Vol. xxix—1910, pp. 1625-1653

Analytical discussion of commutation in direct-current generators and synchronous converters, with reference to the advantages and disadvantages of commutating poles. General summary of the factors that limit the economical output of various types of converters.

*Discussion*, pp. 1654-1678, by Messrs. Gano Dunn, H. F. T. Erben, C. P. Steinmetz, Jens Bache-Wiig, P. M. Lincoln, J. L. Burnham, C. W. Stone, C. A. Adams, and B. G. Lamme.

General remarks on the use of commutating poles in synchronous converters, with special reference to interurban service where load factor is very low. Additional data on the design and limiting factors in synchronous converter construction.

## 12. PARALLEL OPERATION

### ANGULAR VARIATION IN STEAM ENGINES

P. O. Keilholtz

Vol. xviii—1901, pp. 703-740

Mathematical investigation of the turning moments due to steam and to inertia of the reciprocating parts, developing method of determining the relation between balancing effect of fly-wheel and the deviation from the position of absolutely uniform speed. Description of method of measuring any velocity variations by means of electrically driven tuning fork with detailed results of tests on a tandem compound engine.

*Discussion*, incorporated with that of paper by Walter I. Slichter on "Angular Velocity in Steam Engines in Relation to Paralleling of Alternators."

### SPEED REGULATION OF PRIME MOVERS AND PARALLEL OPERATION OF ALTERNATORS

Charles P. Steinmetz

Vol. xviii—1901, pp. 741-744

Brief consideration of the features of speed regulation that affect parallel operation of alternators.

*Discussion*, incorporated with that of paper by W. I. Slichter on "Angular Velocity in Steam Engine in Relation to Paralleling of Alternators."

### PARALLEL OPERATION OF ENGINE-DRIVEN ALTERNATORS

W. L. R. Emmet

Vol. xviii—1901, pp. 745-751

Account of the development of an anti-surfing device for application to engine governors to enable parallel operation of alternators under all conditions of load.

*Discussion*, incorporated with that of paper by W. I. Slichter on "Angular Velocity in Steam Engine in Relation to Paralleling of Alternators."

### PARALLEL RUNNING OF ALTERNATORS

Ernst J. Berg

Vol. xviii—1901, pp. 753-757

Development of equation covering the principles of parallel operation of alternators, showing the effect of armature reaction, the cause of hunting and remedy.

*Discussion*, incorporated with that of paper by W. I. Slichter on "Angular Velocity in Steam Engine in Relation to Paralleling of Alternators."

### ANGULAR VELOCITY IN STEAM ENGINES IN RELATION TO PARALLELING OF ALTERNATORS

Walter I. Slichter

Vol. xviii—1901, pp. 759-771

Analytical discussion of causes and effects of irregular crank effort. Actual analysis of performance of engine of given design.

*Discussion* (included with that of paper by P. O. Keilholtz on "Angular Variations in Steam Engines," paper by Chas. P. Steinmetz on "Speed

Regulation of Prime Movers and Parallel Operation of Alternators," paper by W. L. R. Emmett on "Parallel Operation of Engine Driven Alternators," and paper by Ernst J. Berg on "Parallel Running of Alternators"), pp. 772-800, by Messrs. R. H. Rice, Jas. A. Seymour, C. F. Scott, R. D. Mershon, W. L. R. Emmet, B. A. Behrend, and August H. Kruesi.

General remarks on requirements of parallel operation of alternators and cause and remedy for hunting. Relation between regulation characteristics of engine and division of load. Methods of measuring angular deviation.

#### OPERATION OF SYNCHRONOUS CONVERTERS

S. C. Lindsay

Vol. xxiii—1904, pp. 345-351

Account of experience with the parallel operation of 60-cycle synchronous converter, where much trouble was experienced from hunting.

No discussion.

#### NOTES ON FLY-WHEELS

H. H. Barnes, Jr.

Vol. xxiii—1904, pp. 353-363

Analytical study of relation of fly-wheel effect to hunting, giving directions for predetermining the natural frequency of oscillation of a given system.

*Discussion*, pp. 461-466, by Messrs. H. H. Barnes, Jr., W. S. Franklin, Clarence P. Feldman, and H. Y. Hall, Jr.

General remarks on hunting of water turbine, gas engine and steam engine driven machines.

#### CONDITIONS FOR CONTINUOUS SERVICE OVER LINES OPERATED IN PARALLEL

M. H. Gerry, Jr.

Vol. xxiii—1904, pp. 547-550

Brief description of method of operating two transmission lines in parallel. Wiring diagram.

*Discussion*, p. 551, by Messrs. Ralph D. Mershon and P. H. Thomas.

#### SOME FEATURES AFFECTING THE PARALLEL OPERATION OF SYNCHRONOUS MOTOR-GENERATOR SETS

J. B. Taylor

Vol. xxv—1906, pp. 113-136

Analysis of phenomena causing unequal division of load between synchronous motor-generator sets, with requirements in design, construction and operation necessary to overcome these difficulties. Tests showing magnitude and character of unbalanced condition. Detailed directions for starting synchronous motor-generator sets.

*Discussion*, pp. 137-138, by Messrs. W. L. Waters and J. B. Taylor.

Experience in parallel operation of synchronous motor-generator sets.

## INTERACTION OF SYNCHRONOUS MACHINES

Morgan Brooks

Vol. xxvi—1907, pp. 1027-1046

Development of a circle diagram for representing the physical relations and quantities of ideal synchronous machines in parallel operation. Mathematical analysis of the problem and expressions for the input, output, losses, efficiency and synchronizing power.

*Discussion*, pp. 1047-1048, by Messrs. E. J. Berg, Charles P. Steinmetz, and Comfort A. Adams.

Practical limitations of Professor Brook's method. Origin of the circle diagram used in the paper.

## PARALLEL OPERATION OF HYDROELECTRIC PLANTS

W. S. Lee

Vol. xxix—1910, pp. 547-557

General discussion of some of the economic advantages of operating hydroelectric plants in parallel, with all plants tied into one large high-tension distribution system, based on experience with plants of the Southern Power Company located on the southern slopes of the Appalachian Mountains.

*Discussion*, pp. 558-571, by Messrs. W. S. Lee, Charles E. Waddell, Percy H. Thomas, David B. Rushmore, A. M. Schoen, Carl Hering, H. N. Muller, W. L. Waters, Charles F. Scott, and Edward W. Shedd.

General discussion of the parallel operation of hydroelectric plants, with special reference to the use of induction generators and the regulation of speed and e. m. f.

## PARALLEL OPERATION OF THREE-PHASE GENERATORS, WITH THEIR NEUTRALS INTERCONNECTED

George I. Rhodes

Vol. xxix—1910, pp. 765-790

Analytical development of the relations between the factors that produce neutral currents in star-connected generators with interconnected neutrals, so as to permit a close predetermination of the magnitude of the currents, followed by an application of the equation to existing generators, the results being checked by tests. Remedies for the prevention of these currents are suggested.

*Discussion*, pp. 791-807, by Messrs. H. J. Ryan, S. J. Lisberger, G. I. Rhodes, C. L. Cory, L. B. Stillwell, C. F. Adams, Paul Downing, E. F. Scattergood, W. F. Lamme, P. M. Lincoln, C. A. Adams, S. B. Charters, Jr., W. A. Hillebrand, Ralph D. Mershon, and H. Y. Hall.

Some experience with plants operating with star-connected generators with interconnected neutrals. Laboratory reproduction of these conditions. Feasibility of applying author's remedies.

### 13. TRANSMISSION LINES

#### A. STRUCTURAL FEATURES

##### THE ELECTRIC TRANSMISSION OF POWER FROM NIAGARA FALLS

Lewis B. Stillwell

Vol. xviii—1901, pp. 445-531

Historical outline of the development, design, construction and operation of the electrical equipment of the Niagara Falls power plant. Description of the generators, their design and their performance under tests and in operation. Also a description of the transmission and distribution system, its construction and difficulties encountered in its operation.

*Discussion*, pp. 532-544, by Messrs. L. B. Stillwell, Chas. P. Steinmetz, H. W. Buck, P. M. Lincoln, E. A. Sperry, F. A. C. Perrine, P. K. Stern, H. G. Stott, and Clarence E. Gifford.

General discussion of the methods of operation for large transmission and distribution systems with reference to interruptions from various causes. Experience with grounded wire on long lines in the West. Difficulties in operation of railway converter sub-stations in Buffalo.

##### THE BUFFALO HIGH-TENSION CABLE DISTRIBUTION SYSTEM

Harold W. Buck

Vol. xviii—1901, pp. 835-841

General description of system of distribution of Niagara power in Buffalo.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

##### MECHANICAL SPECIFICATIONS OF THE PROPOSED STANDARD INSULATOR PIN

Ralph D. Mershon

Vol. xxi-1903, pp. 233-237

Mathematical investigation of fiber stresses in wooden insulator pins with design and dimensions recommended for standard practice.

*Discussion*, incorporated with that of paper by W. S. Franklin on "Model Showing Distribution of Electromotive Force and Current Along a Single-Phase Alternating-Current Transmission Line."

##### THE TESTING OF INSULATORS

F. O. Blackwell

Vol. xxi—1903, pp. 239-243

Factors which enter into the selection and testing of line insulators, based upon actual experience in the operation of high-tension lines.

*Discussion*, incorporated with that of paper by W. S. Franklin on "Model Showing Distribution of Electromotive Force and Current Along a Single-Phase Alternating-Current Transmission Line."

**BURNING OF WOODEN PINS ON HIGH TENSION TRANSMISSION LINES**

C. C. Chesney

Vol. xxi—1903, pp. 253-260

Brief report of experience with charring of wooden pins in California, with photographs of the damaged pins.

*Discussion*, incorporated with that of paper by W. S. Franklin on "Model Showing Distribution of Electromotive Force and Current Along a Single-Phase Alternating-Current Transmission Line."

**METHODS OF BRINGING HIGH-TENSION CONDUCTORS INTO BUILDINGS**

C. E. Skinner

Vol. xxii—1903, pp. 313-318

Conditions that determine the choice of construction for line entries, and requirements that must be met by such constructions. Examples of medium and high-tension entries.

*Discussion*, pp. 319-329, by Messrs. Henry Floy, O. H. Ensign, A. L. Mudge, F. C. Pierce, J. Harisberger, R. F. Hayward, V. G. Converse, P. H. Thomas, P. M. Lincoln, and Louis Bell.

Description and sectional drawings of various types of high-tension entries in actual use.

**AN EFFICIENT HIGH-PRESSURE WATER-POWER TRANSMISSION PLANT**

George J. Henry, Jr. and Joseph N. LeConte

Vol. xxi—1903, pp. 627-645

General description of Pelton wheels and hydraulic equipment for 1,923-foot head. Methods of making performance tests, the results of tests being given in tables and curves.

*Discussion*, pp. 646-647, by Messrs. F. O. Blackwell and H. A. Lardner.

First three-phase transmission plant in United States. Pipe lines for high pressure.

**OVERHEAD HIGH-TENSION DISTRIBUTING SYSTEMS IN SUBURBAN DISTRICTS**

George H. Lukes

Vol. xxii—1903, pp. 735-739

General discussion of the construction and operation of a satisfactory distribution system for suburban towns and villages surrounding a large city.

*Discussion*, incorporated with that of paper by W. C. L. Eglin on "Safeguards and Regulations in Operation of Overhead Distributing Systems."

**SAFEGUARDS AND REGULATIONS IN OPERATION OF DISTRIBUTING SYSTEMS**

W. C. L. Eglin

Vol. xxii—1903, pp. 747-754

General specifications for the material and construction of overhead distribution systems so as to attain a high degree of safety in operation. Method of testing pole transformers that are damaged by lightning disturbances.

*Discussion* (including that of paper by George H. Lukes on "Overhead High-Tension Distributing Systems in Suburban Districts," and paper by



## A. STRUCTURAL FEATURES OF TRANSMISSION LINES 89

E. J. Bechtel on "Automatic Apparatus for Regulating Generator and Feeder Potentials"), pp. 755-765, by Messrs. H. B. Gear, G. T. Hanchett, Ralph D. Mershon, Calvert Townley, P. M. Lincoln, M. P. Ryder, George F. Sever, H. G. Stott, W. C. L. Eglin, A. C. Pratt, C. F. Scott, S. P. Grace, and C. H. Chalmers.

Analysis of accidents which interrupt service of overhead distribution systems and general rules for minimizing them. Construction of lines through trees. Rules for the protection of telephone lines from power lines.

### EUROPEAN PRACTICE IN THE CONSTRUCTION AND OPERATION OF HIGH-PRESSURE TRANSMISSION LINES AND INSULATORS

Guido Semenza

Vol. xxiii—1904, pp. 147-163

Outline of method of designing transmission lines, selecting conductor section, line material and type of construction so as to attain proper balance between fixed and operating charges. Notes on relative merits of iron and wooden poles with comparative costs. Factors which enter into the design of insulators.

*Discussion*, pp. 164-168, by Messrs. W. N. Smith, B. J. Arnold, L. L. Perry, W. S. Dix, J. W. Lieb, Jr., C. F. Scott, N. J. Neall, and W. A. Blanck.

Relative merits of steel and wooden pole line construction.

### LONG SPANS FOR TRANSMISSION LINES

F. O. Blackwell

Vol. xxiii—1904, pp. 511-521

Mechanical features in the design of long-span steel tower lines, giving the physical properties of copper, aluminum, iron and steel cable; sag span curves and equations, and tower construction.

*Discussion*, pp. 523-545, by Messrs. Ralph D. Mershon, F. O. Blackwell, A. S. Hatch, Charles F. Scott, N. J. Neall, William Hoopes, Eugene Clark, W. D. Ball, F. A. C. Perrine, W. B. Jackson, H. B. Alverson, Peter Junkersfeld, B. J. Arnold, H. C. Wirt, S. B. Storer, and R. F. Hayward.

General discussion of the relative merits and costs of metal poles and towers vs. wooden poles. Actual and estimated costs of different kinds of line construction.

### ANSWERS TO QUESTIONS RELATIVE TO HIGH-TENSION TRANSMISSION

Vol. xxiii—1904, pp. 571-604

Report of High-Tension Committee giving questions and answers representing the actual standard practice in high-tension transmission line construction and operation.

*Discussion*, pp. 605-614, by Messrs. J. H. Finney, Ralph D. Mershon, Peter Junkersfeld, B. J. Arnold, L. Schuler, S. B. Storer, F. A. C. Perrine, Eugene Clark, W. B. Jackson, N. J. Neall, James Lyman, W. G. Carlton.

Charles F. Scott, G. N. Eastman, H. B. Alverson, F. Woodmansee, and G. R. Radley.

Protection of high-tension crossings by nets, grounded rings, etc. Percentage of total investment represented by transmission circuits. Comparative disturbance produced by opening high-tension air-break and oil-break switches. Experience with static discharges.

#### THE DEVELOPMENT OF THE ONTARIO POWER COMPANY

P. N. Nunn

Vol. xxiv—1905, pp. 807-833

Description of the layout and construction of the generating and distribution plants, profusely illustrated with photographs and working drawings.

*Discussion*, pp. 834-838, by Messrs. Gano S. Dunn, W. E. Goldsborough, H. G. Stott, P. H. Thomas, C. A. Greenidge, P. N. Nunn, and Philip P. Barton.

Probable effect of taking water at Chicago upon the flow at Niagara Falls. Characteristics of ice formation in the Niagara River and cause of ice difficulties experienced by Niagara Falls Power Company.

#### HIGH-TENSION OUTLETS

Alvin Meyers

Vol. xxv—1906, pp. 865-880

Experience with home-made outlet bushings on the Telluride Power Company's system. Complete specifications for construction and installation of 44,000-volt bushings, together with cost of material and labor.

No discussion.

#### TRANSMISSION LINE TOWERS AND ECONOMICAL SPANS

D. R. Scholes

Vol. xxvi—1907, pp. 1221-1237

Derivation of mathematical expression for the weight of steel towers in terms of the stresses and establishment of relation between cost and width of base. Application of equations to determination of most economical span under given conditions.

*Discussion*, incorporated with paper by Norman Rowe on "Lightning-Rods and Grounded Cables as a Means of Protecting Transmission Lines Against Lightning."

#### A NEW TYPE OF INSULATOR FOR HIGH-TENSION TRANSMISSION LINES

E. M. Hewlett

Vol. xxvi—1907, pp. 1259-1262

Illustrated description of the Hewlett link insulator.

*Discussion*, incorporated with paper by H. W. Buck on "Some New Methods in High-Tension Line Construction."

## A. STRUCTURAL FEATURES OF TRANSMISSION LINES 91

### SOME NEW METHODS IN HIGH-TENSION LINE CONSTRUCTION

H. W. Buck

Vol. xxvi—1907, pp. 1263-1269

Brief description of transmission line construction with link type insulators, followed by list of advantages.

*Discussion* (including that of paper by E. M. Hewlett on "A New Type of Insulator for High-Tension Transmission Lines"), pp. 1270-1271, by Messrs. J. B. Whitehead, Ralph D. Mershon, Ralph W. Pope, F. B. H. Paine, and Charles P. Steinmetz.

Brief remarks on potential distribution between successive disks.

### THE TRANSMISSION PLANT OF THE NIAGARA, LOCKPORT AND ONTARIO POWER COMPANY

Ralph D. Mershon

Vol. xxvi—1907, pp. 1273-1313

Description of the line construction and sub-station equipment. Profusely illustrated.

*Discussion*, pp. 1314-1317, by Messrs. E. J. Berg, Ralph D. Mershon, J. W. Fraser, and F. B. H. Paine.

Relative merits of metallic and concrete tower footings, with test results as to the holding-down power of the former.

### LOCATION OF BROKEN INSULATORS AND OTHER TRANSMISSION LINE TROUBLES

L. C. Nicholson

Vol. xxvi—1907, pp. 1319-1329

Description of method of test and derivation of formulas of calculating distance to fault.

*Discussion*, pp. 1330-1331, by Messrs. L. T. Robinson, Ralph D. Mershon, and F. B. H. Paine.

Further elaboration of the method to increase its accuracy.

### SOME POWER TRANSMISSION ECONOMICS

Frank G. Baum

Vol. xxvi—1907, pp. 1555-1569

Description of 60,000-volt transmission line construction used by California Gas and Electric Corporation. Designs for pole tops for spans of from 500 to 3,000 feet; home-made oil switches; outdoor switches, etc.

*Discussion*, pp. 1570-1572, by Messrs. Charles P. Steinmetz and F. B. H. Paine.

Difference between transmission line practice in the West and the East.

### FUNDAMENTAL CONSIDERATIONS GOVERNING THE DESIGN OF TRANSMISSION-LINE STRUCTURES

D. R. Scholes

Vol. xxvii—1908, pp. 931-938

Brief discussion of the mechanical forces that enter into the design of transmission towers—wind pressure, sleet, breakage of lines and mechanical resistance of footings.

*Discussion*, pp. 939-944, by Messrs. N. J. Neall and Ralph Bennett.

General remarks on factors of safety and design of footings. Description of a method of testing towers. Data from the Kern River transmission system.

## THE TESTING OF HIGH VOLTAGE LINE INSULATORS

C. E. Skinner

Vol. xxvii—1908, pp. 945-951

Proposed specifications for routine and design testing of high-tension line insulators.

*Discussion*, pp. 952-958, by Messrs. Percy H. Thomas, Ralph D. Mershon, Clayton H. Sharp, E. M. Hewlett, Chas. P. Steinmetz, C. E. Skinner, and N. J. Neall.

General remarks on insulator test specifications, with special reference to methods of making the rain test.

## THE DEVELOPED HIGH TENSION NET-WORK OF A GENERAL POWER SYSTEM

Paul M. Downing

Vol. xxix—1910, pp. 705-719

Brief description of the Pacific Gas & Electric Company's system, with reference to the method of operation through a load dispatcher and also as to practice regarding connection, care and operation of transformers; construction of large capacity high-tension oil switches; lightning arresters and line insulators.

*Discussion*, pp. 720-729, by Messrs. Markham Cheever, L. B. Stillwell, L. R. Jorgensen, E. F. Scattergood, W. F. Wells, John Harisberger, P. M. Downing, A. M. Hunt, A. O. Austin, and C. F. Adams.

General remarks on the operation of very large high-tension distribution systems, with special reference to the automatic disconnection of disabled lines; the operation of telephone lines paralleling power lines, and the design of large capacity oil switches.

## TRANSMISSION LINE CROSSINGS OF RAILROAD RIGHTS-OF-WAY

Allen H. Babcock

Vol. xxix—1910, pp. 905-909

A brief statement of the problem of transmission line crossing over railways, followed by general specifications for the construction of line crossing over the tracks of the Southern Pacific Railroad.

*Discussion*, pp. 910-926, by Messrs. John Harisberger, A. H. Babcock, A. M. Hunt, C. F. Adams, Lewis B. Stillwell, P. M. Downing, Markham Cheever, Sidney Sprout, J. P. Jollyman, R. W. Van Norden, Ralph D. Mershon, Frank F. Fowle, and Percy H. Thomas.

Criticisms and remarks on the Southern Pacific's suggested specifications.

## B. ELECTRICAL FEATURES

## THE DISTRIBUTION AND CONVERSION OF RECEIVED CURRENTS

Henry Gordon Stott

Vol. xviii—1901, pp. 125-152

Brief description of the transmission plant for generation, transformation and transmission of electric energy from Niagara Falls to Buffalo. Discussion of operative features: means adopted for the protection of the system; relative merits of synchronous converters and motor-generators; relative merits of various arc lighting systems; difficulties in synchronizing 60-cycle synchronous motors.

*Discussion*, pp. 153-163, by Messrs. Gano S. Dunn, Calvin W. Rice, H. G. Stott, C. P. Steinmetz, Elias E. Ries, Jos. Sachs, Jno. W. Lieb, Jr., and H. D. Reed.

Characteristics of three-phase induction motors for railway service. Relative performance of air-break and oil-break switches. Experiences with rubber insulated high-voltage cables.

#### PERFORMANCE OF AN ARTIFICIAL FORTY-MILE TRANSMISSION LINE

William S. Aldrich and George W. Redfield

Vol. xviii—1901, pp. 339-360

Description of apparatus used to duplicate a long line and account of performance tests under various conditions. Relation between line charging current and resonant rise. Line performance curves for loads of different power-factors—synchronous motors with under, normal and over excitation and with excitation varied to give constant receiver e. m. f. Wave form observed under various load conditions.

*Discussion*, incorporated with that of paper by E. W. Rice, Jr., on "The Control of High-Voltage Systems of Large Power."

#### ELEMENTS OF DESIGN PARTICULARLY PERTAINING TO LONG-DISTANCE TRANSMISSION

F. A. C. Perrine

Vol. xviii—1901, pp. 361-369

Discussion of effects of line capacity and inductance on regulation, with statement of conditions requisite for best regulation. Qualities of high-tension (50,000 to 60,000 volts) line insulation and the importance of continuity of service.

*Discussion*, incorporated with that of paper by E. W. Rice, Jr., on "The Control of High-Voltage Systems of Large Power."

#### THEORETICAL INVESTIGATION OF SOME OSCILLATIONS OF EXTREMELY HIGH POTENTIAL IN ALTERNATING HIGH POTENTIAL TRANSMISSIONS

Charles Proteus Steinmetz

Vol. xviii—1901, pp. 383-405

Mathematical investigation of the effect of the exponential term in the general equation for alternating-current circuits, followed by numerical examples showing the nature of disturbances due to opening a short circuit on the line and to connecting the line to a source of alternating current energy.

*Discussion*, incorporated with that of paper by E. W. Rice, Jr., on "The Control of High-Voltage Systems of Large Power."

#### THE ELECTRIC TRANSMISSION OF POWER FROM NIAGARA FALLS

Lewis B. Stillwell

Vol. xviii—1901, pp. 445-531

Historical outline of the development, design, construction and operation of the electrical equipment of the Niagara Falls power plant. Description of the generators, their design and their performance under tests and in operation. Also a description of the transmission and distribution system, its construction and difficulties encountered in its operation.

*Discussion*, pp. 532-544, by Messrs. L. B. Stillwell, Chas. P. Steinmetz, H. W. Buck, P. M. Lincoln, E. A. Sperry, F. A. C. Perrine, P. K. Stern, H. G. Stott, and Clarence E. Gifford.

General discussion of the methods of operation for large transmission and distribution systems with reference to interruptions from various causes. Experience with grounded wire on long lines in the West. Difficulties in operation of railway converter sub-stations in Buffalo.

FORMULA FOR CALCULATING THE ELECTROMOTIVE FORCE AT ANY POINT OF A  
TRANSMISSION LINE FOR ALTERNATING CURRENT

M. LeBlanc

Vol. xix—1902, pp. 759-763

*Discussion*, incorporated with that of paper by Chas. P. Steinmetz on "Notes on the Theory of the Synchronous Motor."

HIGH-TENSION TRANSMISSION LINES

Vol. xxi—1903, pp. 229-231

Introduction by President Chas. F. Scott.

THE TESTING OF INSULATORS

F. O. Blackwell

Vol. xxi—1903, pp. 239-243

Factors which enter into the selection and testing of line insulators, based upon actual experience in the operation of high-tension lines.

*Discussion*, incorporated with that of paper by W. S. Franklin on "Model Showing Distribution of Electromotive Force and Current Along a Single-phase Alternating-Current Transmission Line."

TRANSPPOSITION AND RELATIVE LOCATION OF POWER AND TELEPHONE WIRES

P. M. Lincoln

Vol. xxi—1903, pp. 245-251

Outline of electromagnetic and electrostatic disturbances in telephone lines paralleling high-tension lines, with general directions for minimizing such disturbances.

*Discussion*, incorporated with that of paper by W. S. Franklin on "Model Showing Distribution of Electromotive Force and Current Along a Single-phase Alternating-Current Transmission Line."

MODEL SHOWING DISTRIBUTION OF ELECTROMOTIVE FORCE AND CURRENT  
ALONG A SINGLE-PHASE ALTERNATING-CURRENT  
TRANSMISSION LINE

W. S. Franklin

Vol. xxi—1903, pp. 261-262

Description of model and interpretation of its meaning.

*Discussion* (including that of paper by Ralph D. Mershon on "Mechanical Specifications of a Proposed Standard Insulator Pin," paper by F. O. Blackwell on "The Testing of Insulators," paper by P. M. Lincoln on "Transposition and Relative Location of Power and Telephone Wires," and paper by C. C. Chesney on "Burning of Wooden Pins on High-Tension Transmission Lines"), pp. 263-325, by Messrs. C. F. Scott, Ralph

D. Mershon, M. H. Gerry, Jr., Wm. R. C. Corson, W. C. L. Cory, D. L. Huntington, W. N. Smith, P. H. Thomas, P. M. Lincoln, T. W. Shock, F. N. Waterman, C. C. Chesney, W. L. Waters, C. E. Skinner, C. O. Mailloux, C. L. de Muralt, Philip Torchio, J. R. Armstrong, F. S. Woodward, Henry Floy, D. C. Jackson, F. S. Jones, F. A. C. Perrine, ———, Hodges, Washington Devereux, Carl Hering, Chas. Hewitt, Jas. T. Hutchins, H. F. Sanville, Thomas Spencer, W. G. Carlton, Ernest Gonzenbach, H. H. Wait, A. H. Hatch, J. R. Cravath, H. Etheridge, P. H. Thomas, J. S. Peck, and Budd Frankenfield.

General discussion of insulator pins—calculation of strength, electrical and mechanical tests, wood vs. iron. Relative merits of glass and porcelain insulators; tests. Telephone line disturbances from high-tension lines.

#### CHOICE OF FREQUENCY FOR VERY LONG LINES

P. M. Lincoln

Vol. xxii—1903, pp. 373-376

General discussion of the relative advantages of 60 and 25 cycles for a 200-mile transmission line as regards voltage regulation, charging current and resonance.

*Discussion*, pp. 377-384, by Messrs. B. A. Behrend, F. G. Baum, C. F. Scott, C. O. Mailloux, H. G. Stott, Ralph D. Mershon, D. B. Rushmore, P. M. Lincoln, F. A. C. Perrine and H. A. Storrs.

Equation for natural frequency of transmission line with distributed capacity and inductance. Choice of frequency with reference to the operation of the plant as a whole.

#### THE CONDUCTIVITY OF THE ATMOSPHERE AT HIGH VOLTAGES

Harris J. Ryan

Vol. xxiii—1904, pp. 101-134

Analytical discussion of corona phenomena, reviewing previous experiments of the author and others, followed by account of experimental investigation of corona losses in the laboratory with a cathode tube wave tracer, showing effects of conductor dimensions and atmospheric conditions upon critical voltage, all of which are expressed in equation for critical e. m. f.

*Discussion*, pp. 135-145 and 168-170, by Messrs. C. F. Scott, Samuel Sheldon, Harold B. Smith, P. H. Thomas, Harris J. Ryan, P. M. Lincoln, G. T. Hanchett, Elihu Thomson, Ralph D. Mershon, S. M. Kintner, H. W. Fisher, W. A. Blanck, and C. E. Freeman.

General remarks on losses to atmosphere at high e. m. f.'s, with special reference to the critical e. m. f. and the factors which affect it. Difficulties in measuring very high e. m. f.'s.

#### OIL SWITCHES FOR HIGH PRESSURES

E. M. Hewlett

Vol. xxiii—1904, pp. 215-216

Comparison of oil-break with air-break switches.

*Discussion*, pp. 217-224, 242-245 and 249-251, by Messrs. C. C. Chesney,

F. A. C. Perrine, Alex Dow, Ralph D. Mershon, C. F. Scott, P. N. Nunn, C. L. de Muralt, H. F. Parshall, W. A. Blanck, James Lyman, P. Junkersfeld, W. G. Carlton, E. O. Sessions, G. N. Eastman, I. E. Brooke, P. H. Thomas, R. F. Schuchardt, Edw. Schildhauer, H. F. Sanville, W. C. L. Eglin.

Experience with oil switches in many large plants. Accounts of tests under short-circuit conditions. Specifications for oil switches and brief reference to some of the mechanical difficulties encountered with present types.

#### WAVE FORM VARIATIONS OF A LONG-DISTANCE LINE

George H. Rowe

Vol. xxlii—1904, pp. 403-415

Oscillographic records of wave form at different parts of the Standard Electric Company's transmission system under various conditions of operation. Observations showing effect of wave distortion on transformer core losses.

Discussion, p. 469, by B. J. Arnold.

#### CONDITIONS FOR CONTINUOUS SERVICE OVER LINES OPERATED IN PARALLEL

M. H. Gerry, Jr.

Vol. xxlii—1904, pp. 547-550

Brief description of method of operating two transmission lines in parallel. Wiring diagram.

Discussion, p. 551, by Messrs. Ralph D. Mershon and P. H. Thomas.

#### THE TRANSPOSITION OF ELECTRICAL CONDUCTORS

Frank F. Fowle

Vol. xxlii—1904, pp. 659-687

Mathematical development of the theoretical inductance and capacity constants of a system of line conductors. Empirical rules for transposition and discussion of method of dealing with problems under various conditions, such as are met in actual practice.

Discussion, p. 689, by Messrs. W. S. Franklin, F. F. Fowle, and W. J. Lansley.

#### AN EXPERIMENTAL STUDY OF THE RISE OF POTENTIAL ON COMMERCIAL TRANSMISSION LINES DUE TO STATIC DISTURBANCES CAUSED BY SWITCHING, GROUNDING, ETC.

Percy H. Thomas

Vol. xxiv—1905, pp. 317-354

Brief statement of the principles underlying resonance phenomena in commercial circuits, followed by record of tests on actual transmission lines, showing effect of connecting circuits under many different conditions of grounding, of resonance and of various static disturbances. Also tests of line losses to air and over insulators.

Discussion (including that of paper by Charles P. Steinmetz on "High-Power Surges in Electric Distribution Systems of Great Magnitude"), pp. 355-369, by Messrs. H. G. Stott, P. N. Nunn, S. M. Kintner, F. A. C.



## B. ELECTRICAL FEATURES OF TRANSMISSION LINES 97

Perrine, H. W. Fisher, J. W. Lieb, Jr., Samuel Sheldon, Charles P. Steinmetz, and Percy H. Thomas.

General remarks on surges and their probable causes. Description of expedients adopted by the Interborough Rapid Transit Company to avoid high-power surges.

### LINE CONSTANTS AND ABNORMAL VOLTAGES AND CURRENTS IN HIGH-POTENTIAL TRANSMISSIONS

Ernst J. Berg

Vol. xxvi—1907, pp. 163-178

Equations for calculation of transmission line constants. Theoretical investigation of stresses in electric transmission systems resulting from opening and closing switches, arcing grounds, leaks, etc. Investigation of corona on non-grounded system.

*Discussion*, p. 178, by Mr. Frank G. Baum.

Voltage rise due to interrupting given current.

### SWITCHBOARD PRACTICE FOR VOLTAGES OF 60,000 AND UPWARDS

Stephen Q. Hayes

Vol. xxvi—1907, pp. 1333-1357

Brief general discussion of factors which enter into the choice and arrangement of control apparatus in high-tension plants, with special reference to oil switches and circuit breakers. Designs for 60,000 and 100,000-volt stations given to demonstrate the relative space required.

*Discussion*, pp. 1358-1362, by Messrs. P. M. Lincoln, F. B. H. Paine, D. B. Rushmore, H. W. Buck, J. B. Taylor, William McClellan, W. N. Smith, L. C. Nicholson, S. Q. Hayes, J. H. Finney, F. G. Baum, and Ralph D. Mershon.

Use of extra line wire for emergency service. Method of tying conductors to pin type insulators.

### HIGH VOLTAGE MEASUREMENTS AT NIAGARA

Ralph D. Mershon

Vol. xxvii—1908, pp. 845-903

Detailed account of tests on high tension lines, covering the losses to atmosphere by corona, leakage over insulators, etc., with various spacings, conductor diameters, frequencies and atmospheric conditions; also the effect of the various factors upon the occurrence of the critical voltage. Most data is presented in graphic form. In conclusion there are 22 items that have a distinct bearing upon the operation of very high-tension lines, and which have been deduced from the results of those tests and those made at Telluride and by Professor Ryan.

*Discussion*, pp. 904-929, by Messrs. Henry Doherty, Elihu Thomson, Samuel Sheldon, Henry Floy, Chas. P. Steinmetz, Percy H. Thomas, P. M. Lincoln, Carl Hering, Chas. F. Scott, A. E. Kennelly, W. L. Waters, and N. M. Snyder.

General discussion of line and insulator losses at high tension. Definition of critical point and explanation of physical meaning of relation between atmospheric losses and vapor product. Analysis of insulator losses.

## THE TESTING OF HIGH VOLTAGE LINE INSULATORS

C. E. Skinner

Vol. xxvii—1908, pp. 945-951

Proposed specifications for routine and design testing of high-tension line insulators.

*Discussion*, pp. 952-958, by Messrs. Percy H. Thomas, Ralph D. Mershon, Clayton H. Sharp, E. M. Hewlett, Chas. P. Steinmetz, C. E. Skinner, and N. J. Neall.

General remarks on insulator test specifications, with special reference to methods of making the rain test.

## A TRIGONOMETRIC METHOD FOR THE SOLUTION OF ALTERNATING-CURRENT PROBLEMS

Harold Pender

Vol. xxvii—1908, pp. 1397-1424

Development of a short method for solving alternating-current problems with examples of its application to single-phase and three-phase transmission lines, transformer and induction motors. Tables of reactance capacity, resistance and drop factors for use in such calculations.

*Discussion*, pp. 1424-1427, by Messrs. Comfort A. Adams, W. A. Del Mar, and L. W. Rosenthal.

Magnitude of errors involved by this method when applied to transmission line calculations.

## CONDENSER TYPE OF INSULATION FOR HIGH-TENSION TERMINALS

A. B. Reynnders

Vol. xxviii—1909, pp. 209-220

Theory, construction and tests of special form of high-tension terminal bushing built with alternate layers of metal foil and insulation.

*Discussion*, pp. 221-268, including that of K. C. Randall's paper on "High-tension Transformers and Protective and Controlling Apparatus for Outdoor Installation," by Messrs. W. S. Moody, Percy H. Thomas, David B. Rushmore, Paul M. Lincoln, E. M. Hewlett, S. Piek, Guido Semenza, A. E. Kennelly, J. S. Peck, Ralph D. Mershon, W. S. Franklin, N. J. Neall, G. Faccioli, C. L. de Muralt, V. D. Moody, M. W. Franklin, A. B. Reynnders, Ralph W. Pope, F. G. Baum, O. S. Lyford, Jr., Carl Schwartz, J. B. Whitehead, John J. Frank, W. L. Waters, L. L. Perry, J. N. Kelman, August H. Kruesi, and D. Kos.

General discussion of the advisability of using outdoor transformer and switching stations. Experience with outdoor high-tension apparatus. Theory and calculation of condenser type bushings. Construction of oil and asphalt-filled insulating bushings.

## OUTPUT AND REGULATION OF LONG-DISTANCE LINES

Percy H. Thomas

Vol. xxviii—1909, pp. 615-640

Theoretical discussion of the limitations of energy transmission for long distances, with special reference to the line output, e. m. f. regulation, and line energy loss. Numerical examples of very long lines, show-

ing the effects of varying the conductance and capacity by various artificial methods.

*Discussion*, incorporated with that of Mr. Percy H. Thomas' paper on "Calculation of High-Tension Line."

#### CALCULATION OF HIGH-TENSION LINE

Percy H. Thomas

Vol. xxviii—1909, pp. 641-686

Derivation and explanation of transmission line equations, together with practical examples.

*Discussion*, pp. 687-723, including discussion of "Output and Regulation of Long-Distance Lines," by Messrs. T. R. Rosebrugh, V. Karapetoff, John B. Taylor, Charles P. Steinmetz, P. M. Lincoln, Ralph D. Mershon, Henry W. Fisher, J. B. Whitehead, Charles F. Scott, A. E. Kennelly, W. A. Del Mar, Percy H. Thomas, and T. Dalmont.

General discussion of long-distance transmission, with several systems of general equations and methods of calculating the performance of long transmission lines. Derivation of wave formula for transmission line calculations.

#### THE DEVELOPED HIGH TENSION NET-WORK OF A GENERAL POWER SYSTEM

Paul M. Downing

Vol. xxix—1910, pp. 705-719

Brief description of the Pacific Gas & Electric Company's system, with reference to the method of operation through a load dispatcher and also as to practice regarding connection, care and operation of transformers; construction of large capacity high-tension oil switches; lightning arresters and line insulators.

*Discussion*, pp. 720-729, by Messrs. Markham Cheever, L. B. Stillwell, L. R. Jorgensen, E. F. Scattergood, W. F. Wells, John Harisberger, P. M. Downing, A. M. Hunt, A. O. Austin, and C. F. Adams.

General remarks on the operation of very large high-tension distribution systems, with special reference to the automatic disconnection of disabled lines; the operation of telephone lines paralleling power lines, and the design of large capacity oil switches.

#### THE ELECTRIC STRENGTH OF AIR

J. B. Whitehead

Vol. xxix—1910, pp. 1159-1187

Description and discussion of an experimental investigation of the dielectric strength of air and the formation of corona around cylindrical conductors, showing effects of temperature, pressure, and dimensions and material of the wire on the dielectric strength of air. Description of a new and very accurate method of testing dielectric strength of air about conductors. Bibliography.

*Discussion*, incorporated with that of Mr. H. W. Tobey's paper on "Dielectric Strength of Oil."

## C. ECONOMICS

## THE MAXIMUM DISTANCE TO WHICH POWER CAN BE ECONOMICALLY TRANSMITTED

Ralph D. Mershon

Vol. xxiii—1904, pp. 759-781

Consideration of the elements which limit the distance to which energy can be transmitted. Curves showing the economical distance for different amounts of energy, different voltages, costs of generators and selling prices. Size of conductors for different distances and powers and profit for different distances and powers. Analysis of the equations in which the costs are expressed in terms of the line constants.

*Discussion*, pp. 782-806, by Messrs. J. W. Lieb, Jr., Philip Torchio, P. G. Gossler, J. E. Wallace, M. H. Gerry, Jr., A. E. Kennelly, Charles F. Scott, C. L. de Muralt, Ralph D. Mershon, S. M. Kintner, P. M. Lincoln, C. E. Skinner, H. W. Fisher, N. J. Neall, William McClellan, A. B. Stitzer, Carl Hering, and H. A. Foster.

General discussion of the author's results and assumptions. Choice of frequency for long-distance transmission lines. Effect of load-factor on competition of transmission plants with steam plants. Limit of price for which transmitted energy can be sold.

## ELECTRIC POWER TRANSMISSION

Frederick Darlington

Vol. xxv—1906, pp. 181-190

General classification of natural water powers and loads which may be carried by such powers. Outline of data that must be determined in developing water power. Preliminary data and detailed estimates of cost of energy production in a certain plant in the Southern Appalachian Mountains; also estimated cost of steam competition.

No discussion.

## SINGLE-PHASE HIGH-TENSION POWER TRANSMISSION

E. J. Young

Vol. xxvi—1907, pp. 1573-1579

Superficial comparison of high-tension direct-current, single-phase with grounded neutral point and three-phase transmission systems on the score of economy.

*Discussion*, pp. 1580-1583, by Messrs. Charles P. Steinmetz, E. H. Schwarz, C. T. Wilkinson, and G. T. Fielding, Jr.

Comparison of single-phase and polyphase systems with grounded neutral. Armature reactance and short-circuit performance of single-phase generators. Some characteristics of the Thury direct-current system.

## SOME ENGINEERING FEATURES OF THE SOUTHERN POWER COMPANY'S SYSTEM

J. W. Fraser

Vol. xxvii—1908, pp. 819-840

General discussion of the reasons that govern the choice of power capacity, frequency, voltage, line construction and sub-station equipment in this particular instance. Outline of the company's policy with refer-

ence to the development of secondary power available only part of the year.

*Discussion*, pp. 841-844, by Messrs. J. H. Finney, W. S. Lee, D. B. Rushmore, P. M. Lincoln, Chas. P. Steinmetz, P. H. Thomas, and J. W. Fraser.

Additional data on the operation of the system. General remarks on the choice of voltage for transmission plants.

## 14. ELECTRIC SERVICE DISTURBANCES AND PROTECTION

### A. PROTECTION OF APPARATUS

#### REVERSE-CURRENT CIRCUIT-BREAKERS AND THE PROTECTION OF TRANSMISSION LINES

Leonard Wilson

Vol. xxii—1903, pp. 303-309

General characteristics and principles of operation of reverse-power relays. Description of Andrews' reverse-power indicator and differential choke coils for preventing the establishment of a reverse power.

*Discussion*, pp. 310-311, by Messrs. H. G. Stott, Leonard Wilson, and Charles F. Scott.

Method of using differential choke coils on any number of parallel feeders.

#### SAFETY DEVICES IN CENTRAL STATIONS AND SUB-STATIONS

Philip Torchio

Vol. xxi—1903, pp. 417-423

Itemized list of expedients to be employed in large central station system to insure the maximum degree of reliability of service.

*Discussion*, incorporated with that of paper by Peter Junkersfeld on "Multiple Versus Independent Operation of Units and Central Stations."

#### THE USE OF AUTOMATIC MEANS FOR DISCONNECTING DISABLED APPARATUS

H. G. Stott

Vol. xxii—1903, pp. 427-430

General recommendation for the protection of generators, transmission lines, synchronous converters and feeders, with reverse power and overload relays with and without time and current limit attachments.

*Discussion* (including that of paper by Henry W. Fisher on "Electric Cables for High Voltage Service," and paper by Philip Torchio on "The Operation and Maintenance of High-Tension Underground Systems"), pp. 431-444, by Messrs. W. F. Wells, Edward P. Burch, Carl Schwartz, W. G. Carlton, W. C. L. Eglin, C. O. Mailloux, Ralph D. Mershon, H. G. Stott, H. W. Fisher, W. L. Waters, R. S. Kelsch, and F. A. C. Perrine.

Experience in the operation of various large high-tension cable systems. General remarks on protection of transmission and distribution plants.

#### THE USE OF GROUP-SWITCHES IN LARGE POWER PLANTS

L. B. Stillwell

Vol. xxiii—1904, pp. 199-202

Wiring layout of Manhattan Railway power plant. Illustrating use of group switches, followed by classified advantages and disadvantages of group switches in this particular instance.

*Discussion*, pp. 204-214, 238-242 and 247-249, by Messrs. Alex Dow, Ralph D. Mershon, H. G. Stott, Lewis B. Stillwell, William B. Jackson, Gilbert Wright, John B. Taylor, H. F. Parshall, W. G. Carlton, J. Junkersfeld, W. A. Blanck, G. N. Eastman, James Lyman, and B. P. Rowe.

General remarks pro and con the use of group switches. Various methods of connecting generators to feeders advocated. Method of clearing short circuit on long lines where power plants are operated in parallel.

#### THE USE OF GROUND-SHIELDS IN TRANSFORMERS

J. S. Peck

Vol. xxiii—1904, pp. 553-554

Description of the nature and purpose of the ground shield and list of objections to its use.

*Discussion*, pp. 555-556, by Messrs. Ralph D. Mershon, H. C. Wirt, C. E. Skinner, P. H. Thomas, and W. L. Waters.

Objections to ground shield. Advantages of grounded neutral.

#### TIME-LIMIT RELAYS

George F. Chellis

Vol. xxiv—1905, pp. 247-259

Classification of time-limit relays. Ideal requirements of relays for the protection of alternating-current generators, feeders and synchronous converters. Characteristic performance curves of relays under various conditions. Wiring diagrams for relay connections.

*Discussion*, incorporated with paper by H. W. Buck on "Duplication of Electrical Apparatus to Secure Reliability of Service."

#### STANDARDIZATION OF ENCLOSED FUSES

H. O. Lacount

Vol. xxiv—1905, pp. 893-913

Account of the events that led up to and of the actual work of developing the National Board of Fire Underwriters specification for enclosed fuses. Copy of the specification.

*Discussion*, pp. 914-918, by Messrs. H. O. Lacount, S. S. Wheeler, L. W. Downes, A. H. Pikler, W. L. Puffer, and H. G. Stott.

Explanation of the cause of potential rise upon blowing of the fuse.

#### PROTECTION OF THE INTERNAL INSULATION OF A STATIC TRANSFORMER AGAINST HIGH-FREQUENCY STRAINS

Walter S. Moody

Vol. xxvi—1907, pp. 1173-1178

Illustrated description of a method of protecting transformers by providing extra insulation on the end turns and bringing out the taps from the center of the winding.

*Discussion*, incorporated with paper by H. W. Tobey on "Notes on Transformer Testing."

#### TESTS WITH ARCING GROUNDS AND CONNECTIONS

Ernst J. Berg

Vol. xxvii—1908, pp. 741-751

Account of tests with arcing grounds on transformers with single-phase and polyphase connections to study the effect of such grounds under

various conditions and indicate the best methods of protecting transformers.

*Discussion*, incorporated with paper by Percy H. Thomas on "Critical Study of Lightning Records on Taylor's Falls Transmission Line."

#### SOME CONSIDERATIONS IN DESIGNING HEAVY CAPACITY FUSES

Louis W. Downes

Vol. xxviii—1909, pp. 947-969

Theory, calculation and design of enclosed fuses, with comparative tests of single and multiple-link enclosed fuses under short-circuit conditions. Oscillograms of short-circuit current and e. m. f.

*Discussion*, pp. 970-974, by Messrs. C. Francis Harding, J. C. Lincoln, W. S. Andrews, A. E. Kennelly, and Louis W. Downes.

Explanation of the function of filling in enclosed fuses, and description of a method of determining energy consumption of fuses without the use of oscillograph.

### B. PROTECTION OF LINES AND CABLES

#### THE OPERATION AND MAINTENANCE OF HIGH-TENSION UNDERGROUND SYSTEMS

Philip Torchio

Vol. xxli—1903, pp. 421-425

Brief remarks on the general subject. Record of cable troubles on The New York Edison Company lines. Connections of apparatus for breaking down defective insulation.

*Discussion*, incorporated with that of paper by H. G. Stott on "The Use of Automatic Means for Disconnecting Disabled Apparatus."

#### SAFEGUARDS AND REGULATIONS IN OPERATION OF DISTRIBUTING SYSTEMS

W. C. L. Eglin

Vol. xxli—1903, pp. 747-754

General specifications for the material and construction of overhead distribution systems so as to attain a high degree of safety in operation. Method of testing pole transformers that are damaged by lightning disturbances.

*Discussion* (including that of paper by George H. Lukes on "Overhead High-Tension Distributing Systems in Suburban Districts" and paper by E. J. Bechtel on "Automatic Apparatus for Regulating Generator and Feeder Potentials"), pp. 755-765, by Messrs. H. B. Gear, G. T. Hanchett, Ralph D. Merzhon, Calvert Townley, P. M. Lincoln, M. P. Ryder, George F. Sever, H. G. Stott, W. C. L. Eglin, A. C. Pratt, C. F. Scott, S. P. Grace, and C. H. Chalmers.

Analysis of accidents which interrupt service of overhead distribution systems and general rules for minimizing them. Construction of lines through trees. Rules for the protection of telephone lines from power lines.



PROTECTION OF CABLES FROM ARCS DUE TO THE FAILURE OF ADJACENT CABLES  
W. G. Carlton Vol. xxiii—1904, pp. 471-474

Description of methods of isolating and fire-proofing cables in manholes.

*Discussion*, pp. 475-479, by Messrs. Ralph D. Mershon, W. F. Wells, H. C. Wirt, W. G. Carlton, H. B. Alverson, E. M. Lake, A. M. Hunt, and J. W. F. Blizard.

General remarks on the protection of high-tension cables in manholes and in power houses. Formulas for fire-proof coverings.

HIGH-POWER SURGES IN ELECTRIC DISTRIBUTION SYSTEMS OF GREAT MAGNITUDE  
Charles P. Steinmetz Vol. xxiv—1905, pp. 297-315

Theoretical and mathematical investigation of high-power surge in Manhattan Railway cable distribution system.

*Discussion*, incorporated with paper by Percy H. Thomas on "An Experimental Study of the Rise of Potential on Commercial Transmission Lines Due to Static Disturbances Caused by Switching, Grounding, Etc."

AN EXPERIMENTAL STUDY OF THE RISE OF POTENTIAL ON COMMERCIAL  
TRANSMISSION LINES DUE TO STATIC DISTURBANCES CAUSED  
BY SWITCHING, GROUNDING, ETC.

Percy H. Thomas

Vol. xxiv—1905, pp. 317-354

Brief statement of the principles underlying resonance phenomena in commercial circuits, followed by record of tests on actual transmission lines, showing effect of connecting circuits under many different conditions of grounding, of resonance and of various static disturbances. Also tests of line losses to air and over insulators.

*Discussion* (including that of paper by Charles P. Steinmetz on "High-Power Surges in Electric Distribution Systems of Great Magnitude"), pp. 355-369, by Messrs. H. G. Stott, P. N. Nunn, S. M. Kintner, F. A. C. Perrine, H. W. Fisher, J. W. Lieb, Jr., Samuel Sheldon, Charles P. Steinmetz, and Percy H. Thomas.

General remarks on surges and their probable causes. Description of expedients adopted by the Interborough Rapid Transit Company to avoid high-power surges.

C. LIGHTNING PHENOMENA

STATIC STRAINS IN HIGH TENSION CIRCUITS AND THE PROTECTION  
OF APPARATUS

Percy H. Thomas

Vol. xix—1902, pp. 213-264

Discussion of the nature, causes and effects of disturbances of the potential in a transmission system, such as occur when switches are opened or closed, grounds, short circuits, etc. Description of the mode of operation of the static interrupter and the spark gap lightning arrester with series and shunt resistors. Experimental study of the effects of static disturbances and the degree of protection afforded by choke coils

and static interrupters. Description of mechanical model for demonstrating the travel of waves over a transmission line.

*Discussion*, pp. 265-276, by Messrs. C. P. Steinmetz, F. O. Blackwell, H. W. Fisher, Philip Torchio, P. H. Thomas, and B. A. Behrend.

Results of investigation of needle gap, showing the effect of sharpness on sparking distance; also results of experimental investigation of high-tension transmission line, showing the effects of switching with oil and air break switches. Mathematical study of distribution of potential stress in model as to time and distance measured from time and position of application.

#### LIGHTNING PHENOMENA IN ELECTRIC CIRCUITS

Charles P. Steinmetz

Vol. xxvi—1907, pp. 401-423

Description and classification of lightning phenomena, its causes, effects and methods of protection, with general discussion of static charges, traveling waves and oscillations.

*Discussion*, incorporated with paper by E. E. F. Creighton on "New Principles in the Design of Lightning Arresters."

#### D. LIGHTNING ARRESTERS

##### THE FUNCTION OF SHUNT AND SERIES RESISTANCE IN LIGHTNING ARRESTERS

Percy H. Thomas

Vol. xix—1902, pp. 1021-1034

Principles of operation of low-equivalent lightning arrester. Discussion of the conditions which affect the non-arcing power and experimental determination of laws governing their relations. Brief description of the test apparatus.

*Discussion*, incorporated with that of paper by Charles Edward Skinner on "Energy Loss in Commercial Insulating Materials when Subjected to High Potential Strains."

##### SOME EXPERIENCES WITH LIGHTNING PROTECTIVE APPARATUS

Julian C. Smith

Vol. xxiv—1905, pp. 935-944

Account of three years' experience on the lines of the Shawinigan Water & Power Company, with special reference to horn gap arrester with and without series resistors.

*Discussion*, incorporated with that of paper by N. J. Neall on "Performance of Lightning Arresters on Transmission Lines."

##### NOTE ON LIGHTNING ARRESTERS ON ITALIAN HIGH-TENSION TRANSMISSION LINES

Philip Torchio

Vol. xxiv—1905, pp. 945-949

Description of the Gola series lightning arrester and Friese water resistor static discharger.

*Discussion*, incorporated with that of paper by N. J. Neall on "Performance of Lightning Arresters on Transmission Lines."

## PERFORMANCE OF LIGHTNING ARRESTERS ON TRANSMISSION LINES

N. J. Neall

Vol. xxiv—1905, pp. 951-981

Account of an extensive practical investigation of lightning arresters in service and of lightning disturbances on a large number of transmission lines using tell-tale papers. Full instructions for the use of tell-tale papers, followed by numerous reproductions of performance records and of tell-tale papers and a discussion of their meaning and of the relative merits of different types of protective apparatus.

*Discussion* (including that of paper by Julian C. Smith on "Some Experiences with Lightning Protective Apparatus" and paper by Philip Torchio on "Note on Lightning Arresters on Italian High-Tension Transmission Lines"), pp. 982-998, by Messrs. S. S. Wheeler, P. H. Thomas, Charles F. Scott, W. S. Franklin, J. H. Hallberg, H. C. Wirt, H. A. Pikler, H. G. Stott, Philip Torchio, N. J. Neall, Charles P. Steinmetz, and J. B. Taylor.

General remarks on lightning disturbances and lightning protection. Classification of phenomena, apparatus and its functions. Mode of operation of the overhead grounded wire.

SOME EXPERIENCES WITH LIGHTNING AND STATIC STRAINS ON A  
33,000-VOLT TRANSMISSION SYSTEM

Farley Osgood

Vol. xxv—1906, pp. 349-363

Account of an experience with violent lightning disturbances in the system of the New Milford Power Company, covering results obtained with multigap arresters with series resistor, multigap arresters alone, and multigap arresters with series and shunt resistors.

*Discussion*, incorporated with paper by H. C. Wirt on "Protective Apparatus for Lightning and Static Strains."

## METHODS OF TESTING PROTECTIVE APPARATUS

E. E. F. Creighton

Vol. xxv—1906, pp. 365-397

Classification of lightning disturbances with description of laboratory methods of reproducing the various phenomena. Oscillograms, equivalent needle-gap curves and connection diagrams from tests of lightning arresters. Analytical discussion of the various test methods.

*Discussion*, incorporated with paper by H. C. Wirt on "Protective Apparatus for Lightning and Static Strains."

## PROTECTIVE APPARATUS FOR LIGHTNING AND STATIC STRAINS

H. C. Wirt

Vol. xxv—1906, pp. 399-426

Experimental investigation of the use of resistors in lightning arresters, leading up to the use of multigap arresters with shunt resistors; also tests showing the actual utility of reactive coils and account of experience with overhead grounded wire.

*Discussion* (incorporated with paper by Farley Osgood on "Some Experiences with Lightning and Static Strains on a 33,000-volt Trans-

mission Line" and paper by E. E. F. Creighton on "Methods of Testing Protective Apparatus"), pp. 427-451, by Messrs. H. C. Wirt, C. P. Steinmetz, P. H. Thomas, E. E. F. Creighton, J. B. Taylor, N. J. Neall, P. M. Lincoln, Chas. F. Scott, and Farley Osgood.

General remarks on lightning arresters and lightning protection. Physical and mathematical exposition of theory of multigap arrester with shunt resistors.

#### RECENT INVESTIGATION OF LIGHTNING PROTECTIVE APPARATUS

R. P. Jackson

Vol. xxv—1906, pp. 881-900

Theoretical investigation of lightning phenomena by means of mechanical analogies supplemented by tests tending to show the limitations of inductance of choke coils in protecting transformers and the relative value of the different arc suppressing devices—series resistors, fuses and electrolytic cells, as shown by oscillograms.

*Discussion*, pp. 901-926, by Messrs. Ralph D. Mershon, Chas. P. Steinmetz, Percy H. Thomas, E. E. F. Creighton, H. B. Alverson, P. M. Lincoln, R. P. Jackson, J. F. Vaughan, A. Henry Pikler, and H. W. Buck.

Explanation of action of choke coil under sudden stress and under high frequency stress, including both its inductance and capacity effects. Suggested form of graded resistance lightning arresters. Equivalent gap determination for lightning arrester resistor units with choke coils and lightning rods on separate poles.

#### PROTECTION AGAINST LIGHTNING, AND THE MULTI-GAP LIGHTNING ARRESTER

David B. Rushmore and D. Dubois

Vol. xxvi—1907, pp. 425-459

Collection of photographs of lightning. Brief discussion of characteristics of horn-gap arrester, water jet arrester, grounded wire and choke coils. Theory of operation and description of construction of multi-gap and low equivalent and graded resistance lightning arresters.

*Discussion*, incorporated with paper by E. E. F. Creighton on "New Principles in the Design of Lightning Arresters."

#### NEW PRINCIPLES IN THE DESIGN OF LIGHTNING ARRESTERS

E. E. F. Creighton

Vol. xxvi—1907, pp. 461-486

Description and performance characteristics of multi-gap arrester with graded shunt resistor and electrolytic cell arresters. Theory of operation, oscillograms of current and e. m. f. and design features of the different apparatus.

*Discussion* (including that of paper by Charles P. Steinmetz on "Lightning Phenomena in Electric Circuits" and paper by David B. Rushmore and D. Dubois on "Protection Against Lightning, and the Multi-gap Lightning Arrester"), pp. 487-505, by Messrs. F. A. C. Perrine, Farley Osgood, P. H. Thomas, E. E. F. Creighton, V. G. Converse, D. Dubois, William McClellan, R. P. Jackson, Charles P. Steinmetz, and D. B. Rushmore.

General discussion of the properties of horn-gap, low-equivalent and electrolytic lightning arresters.

## PROTECTIVE APPARATUS ENGINEERING

E. E. F. Creighton

Vol. xxvi—1907, pp. 1049-1095

Glossary of terms used in dealing with lightning phenomena and protective apparatus. Brief discussion of the properties of lightning and characteristics of lightning arresters. Methods of testing lightning arresters so as to fix their various properties. Classification of various types of lightning protective apparatus with short characterization of the limitations and usefulness of each type. General suggestions as to methods of protecting electric plants.

*Discussion*, incorporated with paper by N. J. Neall on "A Proposed Lightning Arrester Test."

## PRACTICAL TESTING OF COMMERCIAL LIGHTNING-ARRESTERS

Percy H. Thomas

Vol. xxvi—1907, pp. 1097-1137

General classification of lightning disturbances, followed by description of tests and testing apparatus required in determining the serviceability of lightning arresters. Tests suggested for standardization by the Institute. Practical limitation of frequency and energy of discharges in commercial lines. List of Institute papers on lightning phenomena. Test curves showing non-arcing power of multigap arresters and shunting power of resistors.

*Discussion*, incorporated with paper by N. J. Neall on "A Proposed Lightning Arrester Test."

## A PROPOSED LIGHTNING-ARRESTER TEST

N. J. Neall

Vol. xxvi—1907, pp. 1139-1144

Description of a method of introducing artificial lightning (recurrent surge) into the transmission circuits, with diagrams of connections of various types of transmission systems.

*Discussion* (including that of paper by E. E. F. Creighton on "Protective Apparatus Engineering" and paper by Percy H. Thomas on "Practical Testing of Commercial Lightning Arresters"), pp. 1145-1154, by Messrs. E. E. F. Creighton, N. J. Neall, Charles P. Steinmetz, P. H. Thomas, W. S. Lee, and Charles E. Waddell.

General remarks on testing of lightning arresters. Actual experience with graded-resistance arrester on star-connected generator.

COMPARATIVE TESTS OF LIGHTNING PROTECTION DEVICES ON THE  
TAYLOR'S FALLS TRANSMISSION SYSTEM

J. F. Vaughan

Vol. xxvii—1908, pp. 397-41

Positive data on transmission line protection covering experience with grounded overhead lines, insulator pins, horn-gap and low-equivalent lightning arresters. Complete log and reproduction of tell-tale papers.

*Discussion*, incorporated with paper by N. J. Neall on "Studies in Lightning Performance, Season 1907."

## STUDIES IN LIGHTNING PERFORMANCE, SEASON 1907

N. J. Neall

Vol. xxvii—1908, pp. 421-448

Analytical study of lightning performance tests on the Taylor's Falls line and on the system of the Presumpscott Electric Company; discussing the nature of lightning phenomena and the effectiveness of protection afforded by lightning rods and different forms of lightning arresters. The present status of the science of lightning protection is briefly summed up in the conclusion. Observed data of lightning performance is given in the Appendix.

*Discussion* (included with the paper by H. St. Clair Putnam on "Conservation of Power Resources"), pp. 459-467, by Messrs. H. W. Buck, P. M. Lincoln, J. F. Vaughan, P. H. Thomas, V. E. Goodwin, E. E. F. Creighton, H. G. Stott, N. J. Neall, and V. D. Moody.

General remarks on lightning protection, with special reference to the protection value of grounded conductors and horn-gap lightning arresters, and the interpretation of tell-tale papers.

## MEASUREMENTS OF LIGHTNING, ALUMINUM LIGHTNING-ARRESTERS, EARTH RESISTANCES, CEMENT RESISTANCES, AND KINDRED TESTS

E. E. F. Creighton

Vol. xxvii—1908, pp. 669-740

Brief description of instruments of measuring duration, potential, current and frequency of lightning. Account of experimental investigation under actual service conditions with different forms of lightning protective devices. Theory and operation of aluminum lightning-arresters. Experimental study of ground connections with respect to ground resistance, inductance and permanence under various conditions. Complete report of exhaustive investigation of cement and concrete as a resistor under various conditions of moisture and temperature.

*Discussion*, incorporated with paper by Percy H. Thomas on "Critical Study of Lightning Records on Taylor's Falls Transmission Line."

## CRITICAL STUDY OF LIGHTNING RECORDS ON TAYLOR'S FALLS TRANSMISSION LINE

Percy H. Thomas

Vol. xxvii—1908, pp. 755-777

Formation of rules for the interpretation of tell-tale papers. Analyses of the storms and the effectiveness of the protection afforded by the various devices—grounded wires, lightning rods, line choke-coils, low equivalent, horn-gap and electrolytic lightning arresters. Explanation of the origin and nature of lightning phenomena.

*Discussion* (included with the paper by E. E. F. Creighton on "Measurements of Lightning, Aluminum Lightning-Arresters, Earth Resistances, Cement Resistances and Kindred Tests," and paper by Ernst J. Berg on "Tests with Arcing Grounds and Connections"), pp. 778-800, by Messrs. J. V. Vaughan, Chas. P. Steinmetz, Paul M. Lincoln, A. E. Kennelly, John B. Taylor, R. H. Marriott, D. B. Rushmore, J. W. Fraser,

W. L. Waters, William McClellan, Farley Osgood, Dugald C. Jackson, E. E. F. Creighton, E. J. Berg, and Percy H. Thomas.

General remarks on the nature of lightning and methods of protecting electrical installations.

#### SURGES ON A CABLE SYSTEM WITH AN ALUMINUM SURGE PROTECTOR

E. E. F. Creighton and S. D. Sprong

Vol. xxviii—1909, pp. 805-839

Experimental investigation with oscillograms of surges on the underground alternating-current distribution system of the United Electric Light & Power Co. of New York with and without aluminum surge protectors.

*Discussion*, pp. 840-849, by Messrs. J. L. R. Hayden, H. W. Fisher, John B. Taylor, Ralph D. Mershon, Charles P. Steinmetz, and E. E. F. Creighton.

Theoretical investigation of the action of the aluminum cell in by-passing a surge. Types, construction, operation and care of aluminum cells.

#### PROTECTION OF ELECTRICAL EQUIPMENT

Paul M. Lincoln

Vol. xxviii—1909, pp. 1157-1167

Explanation of action of surges by means of hydraulic analogy, concluding with classification and brief discussion of various methods of protection.

No discussion.

### E. GROUNDED CONDUCTORS

#### THE GROUNDED WIRE AS A PROTECTION AGAINST LIGHTNING

Ralph D. Mershon

Vol. xxii—1903, pp. 331-336

Outline of theory of static induction in transmission lines from lightning. Effect of grounded wires and method of calculating the magnitude of the shielding action of such wires. General remarks on installation and operation of such wires.

*Discussion*, pp. 337-351, by Messrs. Charles F. Scott, F. A. C. Perrine, C. O. Mailloux, A. I. Wurts, P. H. Thomas, A. E. Kennelly, P. M. Lincoln, F. S. Woodward, D. B. Rushmore, R. S. Kelsch, John F. Kelly, R. F. Hayward, W. L. Waters, D. C. Jackson, Ralph D. Mershon, W. J. Hammer, and W. A. Blanck.

General discussion of the probable performance of overhead grounded wire as protection against external electrostatic disturbances.

#### THE PROTECTION OF HIGH-PRESSURE TRANSMISSION LINES FROM STATIC DISCHARGES

H. C. Wirt

Vol. xxiii—1904, pp. 557-560

Brief general remarks on overhead ground wire, lightning arrester and reactive coils.

*Discussion*, pp. 561-570, by Messrs. J. S. Peck, Ralph D. Mershon, N. J.

Neall, F. O. Blackwell, H. C. Wirt, R. F. Hayward, P. H. Thomas, N. M. Snyder, and John Pearson.

General remarks on lightning protection apparatus and lightning phenomena. Experiences with protective devices and ground wires. Description of method of protecting transformers and windings from potential rises.

#### POTENTIAL STRESSES AS AFFECTED BY OVERHEAD GROUNDED CONDUCTORS

R. P. Jackson

Vol. xxvi—1907, pp. 873-882

Theoretical investigation of potential gradients on equipotential surfaces about grounded conductors in air and about metallic transmission towers. Suggested method of reducing normal stresses in insulators.

*Discussion*, pp. 883-889, by Messrs. P. M. Lincoln, Dugald C. Jackson, D. R. Scholes, H. C. Hoagland, R. P. Jackson, James Lyman, P. B. Woodworth, W. L. Abbott, W. B. Jackson, and George Hayler.

Experience with grounded conductors for transmission line protection.

#### NOTES ON RESISTANCE OF GAS-PIPE GROUNDS

J. L. R. Hayden

Vol. xxvi—1907, pp. 1209-1214

Tests on resistance of gas pipe grounds as affected by temperature and rain. Graphic log of tests extending over about three years. Effect of alternating current on conductance of ground connections.

*Discussion*, pp. 1215-1220, by Messrs. Charles P. Steinmetz, Ralph D. Mereshon, F. B. H. Paine, P. H. Thomas, N. J. Neall, F. J. Hoxie, and J. L. R. Hayden.

Tests on the resistance of concrete foundations of transmission towers and of ground plates, strips and pipes under various conditions.

#### LIGHTNING-RODS AND GROUNDED CABLES AS A MEANS OF PROTECTING TRANSMISSION LINES AGAINST LIGHTNING

Norman Rowe

Vol. xxvi—1907, pp. 1239-1248

Description of Guanajuato transmission line with account of experience with lightning rods and grounded wire.

*Discussion* (including that of paper by D. R. Scholes on "Transmission Line Towers and Economical Spans"), pp. 1249-1257, by Messrs. William Hoopes, P. H. Thomas, W. S. Lee, F. B. H. Paine, C. W. Ricker, George T. Fielding, Jr., N. J. Neall, Ralph D. Mereshon, D. R. Scholes, Frank G. Baum, and Farley Osgood.

Effect of operation cost on economical span. Experience with grounded metal insulator pins and with wooden pins.

#### THE GROUNDED NEUTRAL, WITH AND WITHOUT SERIES RESISTANCE IN HIGH-TENSION SYSTEMS

Paul M. Lincoln

Vol. xxvi—1907, pp. 1585-1595

General discussion of the advantages and disadvantages of the grounded neutral, followed by brief remarks on the making of grounds and the effect of series resistance in the ground circuit.



*Discussion*, incorporated with paper by George I. Rhodes on "Experience with a Grounded Neutral on the High-Tension System of the Interborough Rapid Transit Company."

#### THE GROUNDED NEUTRAL

F. G. Clark

Vol. xxvi—1907, pp. 1597-1603

Some advantages and disadvantages of grounded neutral from experience gained on a large system operated with neutral grounded through a resistor.

*Discussion*, incorporated with paper by George I. Rhodes on "Experience with a Grounded Neutral on the High-Tension System of the Interborough Rapid Transit Company."

#### EXPERIENCE WITH A GROUNDED NEUTRAL ON THE HIGH-TENSION SYSTEM OF THE INTERBOROUGH RAPID TRANSIT COMPANY

George I. Rhodes

Vol. xxvi—1907, pp. 1605-1610

Reasons for installing grounded neutral with series resistor on high-tension cable system. Cross currents between star-connected generators. Relative damage resulting from cable short circuits with and without grounded neutral.

*Discussion* (including that of paper by Paul M. Lincoln on "The Grounded Neutral, with and without Series Resistance, in High-Tension Systems" and that of paper by F. G. Clark on "The Grounded Neutral"), pp. 1611-1641, by Messrs. Peter Junkersfeld, Philip Torchio, N. J. Neall, John B. Taylor, Carl Schwarz, C. W. Stone, F. B. H. Paine, Charles F. Scott, Paul M. Lincoln, George I. Rhodes, Charles P. Steinmetz, Frank G. Baum, and O. S. Lyford, Jr.

Experience with grounded neutral on very large underground cable and overhead transmission systems. Description of device for automatically selecting and disconnecting defective cables.

#### A PRACTICAL METHOD OF PROTECTING INSULATORS FROM LIGHTNING AND POWER ARC EFFECTS

L. C. Nicholson

Vol. xxix—1910, pp. 573-598

Very complete analytical study of three years of carefully recorded insulator experience on 60,000-volt lines of the Ontario Power Company, leading up to the invention of arcing rings and covering one season's experience with them installed.

*Discussion*, pp. 599-620, by Messrs. L. B. Stillwell, F. P. Catchings, J. W. Fraser, E. E. F. Creighton, J. S. Jenks, Charles F. Scott, Percy H. Thomas, J. A. Sanford, Jr., E. B. Merriam, Harris J. Ryan, Irving E. Brooke, James Lyman, Max H. Collbohm, G. Semenza, J. D. E. Duncan, and L. C. Nicholson.

General remarks on transmission line protection. Experience on the West Penn lines (185 miles). Opinions and practice as to insulator factor of safety and efficacy of grounded conductors.

## 15. DISTRIBUTION SYSTEMS

### THE DISTRIBUTION AND CONVERSION OF RECEIVED CURRENTS

Henry Gordon Stott

Vol. xviii—1901, pp. 125-152

Brief description of the transmission plant for generation, transformation and transmission of electric energy from Niagara Falls to Buffalo. Discussion of operative features: means adopted for the protection of the system; relative merits of synchronous converters and motor-generators; relative merits of various arc lighting systems; difficulties in synchronizing 60-cycle synchronous motors.

*Discussion*, pp. 153-163, by Messrs. Gano S. Dunn, Calvin W. Rice, H. G. Stott, C. P. Steinmetz, Elias E. Ries, Jos. Sachs, Jno. W. Lieb, Jr., and H. D. Reed.

Characteristics of three-phase induction motors for railway service. Relative performance of air-break and oil-break switches. Experiences with rubber-insulated high-voltage cables.

### THE DISTRIBUTION BY THE THREE-PHASE SYSTEM AND THE OPERATION OF SINGLE-PHASE CIRCUITS BY IT

W. L. R. Emmet

Vol. xviii—1901, pp. 805-812

Discussion of the use of three-phase generators on single distribution circuits. Wiring diagram for typical systems. General rules for laying out distribution systems.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

### DISTRIBUTION OF ELECTRICAL ENERGY IN LARGE CITIES

Louis A. Ferguson

Vol. xviii—1901, pp. 813-827

General discussion of the load characteristics of the City of Chicago and description of the present system of generation and distribution and the plans for future development. Brief reference to the distribution systems employed in the cities of Berlin and Milan.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

### LOCATING FAULTS IN UNDERGROUND DISTRIBUTION SYSTEMS

Henry G. Stott

Vol. xviii—1901, pp. 829-833

Description of a compass method for quickly and accurately locating faults in power cables through which periodically reversed current is sent. Working drawings of the current reverser.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

## THE BUFFALO HIGH-TENSION CABLE DISTRIBUTION SYSTEM

Harold W. Buck

Vol. xviii—1901, pp. 835-841

General description of system of distribution of Niagara power in Buffalo.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

ALTERNATING CURRENT AS A FACTOR IN GENERAL DISTRIBUTION  
FOR LIGHT AND POWER

Charles P. Scott

Vol. xviii—1901, pp. 843-848

General discussion of the advantages of straight alternating-current generation and distribution for large cities.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

## NOTES ON THE ALTERNATING-CURRENT SYSTEM OF DISTRIBUTION

W. S. Barstow

Vol. xviii—1901, pp. 849-853

Brief sketch of the development of alternating-current distribution system and troubles which were experienced. Conditions which must be met by successful alternating-current distribution system.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

## DISTRIBUTION OF ELECTRICITY IN CITIES OF MODERATE SIZE

William Lispenard Robb

Vol. xviii—1901, pp. 855-860.

General consideration of problem for cities under 50,000 and for those over 50,000.

*Discussion*, incorporated with that of paper by Philip Torchio on "250-Volt Three-Wire Distribution for Lighting and Power."

## 250-VOLT THREE-WIRE DISTRIBUTION FOR LIGHTING AND POWER

Philip Torchio

Vol. xviii—1901, pp. 861-868

Consideration of the relative merits of 500-volt and 250-volt direct-current three-wire systems. Estimated saving of former over latter— with the various densities of load.

*Discussion* (including that of paper by W. L. R. Emmet on "Distribution of Three-Phase System and the Operation of Single-Phase Circuits by It;" paper by Louis A. Ferguson on "Distribution of Electrical Energy in Large Cities;" paper by Henry G. Stott on "Locating Faults in Underground Distribution Systems;" paper by Harold W. Buck on "The Buffalo High-Tension Cable System;" paper by Chas. F. Scott on "Alternating Current as a Factor in General Distribution for Light and Power;" paper by W. S. Barstow on "Notes on an Alternating-Current System of Distribution," and paper by William Lispenard Robb on "Distribution of Electricity in Cities of Moderate Size"), pp. 869-912, by Messrs. C. P. Steinmetz, Gano S. Dunn, Louis A. Ferguson, Arthur Williams, Douglas

Burnett, Fred. V. Henshaw, Jno. W. Lieb, Jr., W. S. Barstow, Philip Torchio, R. H. Pierce, Peter Junkersfeld, Jas. Lyman, A. Osthoff, G. N. Eastman, P. B. Woodworth, G. A. Damon, Geo. Foster, W. D. Ball, J. R. Cravath, D. W. Roper, and W. E. Goldsborough.

General discussion of the relative merits of alternating-current and direct-current distribution for thickly populated districts of large cities. Detailed comparison of the performance and general methods of direct-current and induction motors for different kinds of service. Loop test for locating faults in large cables.

#### OVERHEAD HIGH-TENSION DISTRIBUTING SYSTEMS IN SUBURBAN DISTRICTS.

George H. Lukes

Vol. xxii—1903, pp. 735-739

General discussion of the construction and operation of a satisfactory distribution system for suburban towns and villages surrounding a large city.

*Discussion*, incorporated with that of paper by W. C. L. Eglin on "Safeguards and Regulations in Operation of Overhead Distributing Systems."

#### AUTOMATIC APPARATUS FOR REGULATING GENERATOR AND FEEDER POTENTIALS

E. J. Bechtel

Vol. xxii—1903, pp. 741-745

Performance under service conditions of automatic direct-current and alternating-current generator e. m. f. regulator which operates by decreasing and increasing the field circuit resistance with changes in line e. m. f.

*Discussion*, incorporated with that of paper by W. C. L. Eglin on "Safeguards and Regulations in Operation of Overhead Distributing Systems."

#### SAFEGUARDS AND REGULATIONS IN OPERATION OF DISTRIBUTING SYSTEMS

W. C. L. Eglin

Vol. xxii—1903 pp. 747-754

General specifications for the material and construction of overhead distribution systems so as to attain a high degree of safety in operation. Method of testing pole transformers that are damaged by lightning disturbances.

*Discussion* (including that of paper by George H. Lukes on "Overhead High-Tension Distributing Systems in Suburban Districts" and paper by E. J. Bechtel on "Automatic Apparatus for Regulating Generator and Feeder Potentials"), pp. 755-765, by Messrs. H. B. Gear, G. T. Hanchett, Ralph D. Mershon, Calvert Townley, P. M. Lincoln, M. P. Ryder, George F. Sever, H. G. Stott, W. C. L. Eglin, A. C. Pratt, C. F. Scott, S. P. Grace, and C. H. Chalmers.

Analysis of accidents which interrupt service of overhead distribution systems and general rules for minimizing them. Construction of lines through trees. Rules for the protection of telephone lines from power lines.

**UNDERGROUND TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY**

Charles E. Phelps

Vol. xxvi—1907, pp. 25-30

Classification of cable faults, followed by seven-year record of the performance of various kinds of power, telephone and telegraph cables. Brief analytical discussion of the causes and remedies for these various faults.

No discussion.

**AN ANALYSIS OF THE DISTRIBUTION LOSSES IN A LARGE CENTRAL STATION SYSTEM**

L. L. Elden

Vol. xxvi—1907, pp. 665-680

Record of four years' study of the losses in a certain large energy distribution system, with an account of methods employed to reduce losses between switchboard and consumer.

No discussion.

**ALTERNATING-CURRENT FEEDER REGULATORS**

W. S. Moody

Vol. xxvii—1908, pp. 255-272

Classification and brief discussion of the relative merits of different methods of feeder e. m. f. regulation, followed by description of the construction and operative characteristics of the transformer and induction type regulators. A brief outline of the development of automatic control and description of applications of the Tirrill contact voltmeter to the control of feeder regulators.

*Discussion*, pp. 273-275, by Messrs. R. G. Black, J. Kynoch and R. S. Kelsch.

Experience with the Tirrill and induction type regulators.

**HIGH-POTENTIAL UNDERGROUND TRANSMISSION**

P. Junkersfeld and E. O. Schweitzer

Vol. xxvii—1908, pp. 1499-1527

Description of the underground cable system of the Commonwealth Edison Company of Chicago with records of its performance and results of experiments to determine the magnitude and frequency of occurrence of potential rises in the system.

*Discussion*, pp. 1528-1569, by Messrs. L. A. Ferguson, Charles H. Merz, H. W. Fisher, H. G. Stott, E. J. Berg, Wallace S. Clark, Alex Dow, Warren Partridge, E. E. F. Creighton, L. T. Robinson, Henry Floy, John W. Lieb, Jr., Philip Torchio, Charles P. Steinmetz, E. O. Schweitzer, Peter Junkersfeld, Ralph D. Mershon, H. W. Peck, A. E. Kennelly, N. J. Neall, L. L. Elden, M. V. Ayres, G. W. Palmer, Jr., and Dugald C. Jackson.

Cable experience of various large central stations and transmission companies.

## CONDITIONS AFFECTING STABILITY IN ELECTRIC LIGHTING CIRCUITS

Elihu Thomson

Vol. xxviii—1909, pp. 1-22

Historical résumé of the development of arc lighting machines and systems. Characteristics of arc dynamos; constant-current transformers; mercury arc converters; constant-current and constant-potential arc lamps with special reference to stability of operation.

*Discussion*, pp. 23-50, by Messrs. A. E. Kennelly, Alex Dow, E. W. Rice, Jr., Dugald C. Jackson, C. M. Green, John B. Taylor, H. G. Stott, Elihu Thomson, E. A. Sperry, and Charles P. Steinmetz.

Early experiences with arc lighting systems. Broad definition and examples of various kinds of electrical and mechanical instability. Permanent and transient volt-ampere characteristics of arcs.

## HIGH-VOLTAGE TRANSFORMERS AND PROTECTIVE AND CONTROLLING APPARATUS FOR OUTDOOR INSTALLATION

K. C. Randall

Vol. xxviii—1909, pp. 189-207

Description of types of apparatus, with estimates of relative costs of outdoor and indoor installations. Operation of outdoor transformer stations.

*Discussion*, incorporated with that of A. B. Reynders' paper on "Condenser Type of Insulation for High-Tension Terminals."

## THE DEVELOPED HIGH TENSION NET-WORK OF A GENERAL POWER SYSTEM

Paul M. Downing

Vol. xxix—1910, pp. 705-719

Brief description of the Pacific Gas & Electric Company's system, with reference to the method of operation through a load dispatcher and also as to practice regarding connection, care and operation of transformers; construction of large capacity high-tension oil switches; lightning arresters and line insulators.

*Discussion*, pp. 720-729, by Messrs. Markham Cheever, L. B. Stillwell, L. R. Jorgensen, E. F. Scattergood, W. F. Wells, John Harisberger, P. M. Downing, A. M. Hunt, A. O. Austin, and C. F. Adams.

General remarks on the operation of very large high-tension distribution systems, with special reference to the automatic disconnection of disabled lines; the operation of telephone lines paralleling power lines, and the design of large capacity oil switches.

## 16. CONTROL REGULATION AND SWITCHING

### A. SPEED CONTROL

#### SPEED REGULATION OF PRIME MOVERS PARALLEL OPERATION OF ALTERNATORS

Charles P. Steinmetz

Vol. xviii—1901, pp. 741-744

Brief consideration of the features of speed regulation that affect parallel operation of alternators.

*Discussion*, incorporated with that of paper by W. I. Slichter on "Angular Velocity in Steam Engine in Relation to Paralleling of Alternators."

#### PARALLEL OPERATION OF ENGINE-DRIVEN ALTERNATORS

W. L. R. Emmet

Vol. xviii—1901, pp. 745-751

Account of the development of an anti-surfing device for application to engine governors to enable parallel operation of alternators under all conditions of load.

*Discussion*, incorporated with that of paper by W. I. Slichter on "Angular Velocity in Steam Engine in Relation to Paralleling of Alternators."

#### A NOVEL COMBINATION OF POLYPHASE MOTORS FOR TRACTION PURPOSES

Ernst Danielson

Vol. xix—1902, pp. 527-539

Description of a system of concatenating two motors of unequal numbers of poles so as to get four running speeds. Comparison of acceleration characteristics, torque, energy, efficiency, etc., with direct-current series, plain induction and concatenated induction motors. Abstracted by Dr. Chas. P. Steinmetz on page 495.

*Discussion* (including that of paper by Carl L. DeMuralt on "Some Notes on European Practice in Electric Traction with Three-Phase Alternating Current"), pp. 540-555, by Messrs. C. P. Steinmetz, C. O. Mailloux, Henry G. Stott, W. N. Smith, W. J. Hammer, Townsend Wolcott, Frederick V. Henshaw, and C. L. DeMuralt.

#### A VARIABLE RELUCTANCE METHOD OF MOTOR SPEED CONTROL

G. Fred Packard

Vol. xix—1902, pp. 1131-1141

Reference to earliest work in this direction. Description of the Johnson method of varying the reluctance at the pole face, while maintaining the commutating fringe. Performance tests and flux distribution curves of a Stow motor built on these principles.

*Discussion*, pp. 1142-1143, by Chas. P. Steinmetz, William Esty, G. Fred Packard, P. H. Thomas, and E. B. Raymond.

#### VARIABLE SPEED MOTOR CONTROL

Vol. xx—1902, pp. 111-114

Introduction by President Chas. F. Scott.

#### THREE-WIRE SYSTEM FOR VARIABLE SPEED MOTOR WORK

N. W. Storer

Vol. xx—1902, pp. 127-133

Description of the operation of adjustable speed motors from three-

wire generator, giving advantages of the system and the range of speed variation when combined field and armature control are used.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous Current Motors for Machine Tools."

#### THE STORAGE BATTERY AS A FACTOR IN SPEED CONTROL

H. P. Coho

Vol. xx—1902, pp. 135-138

Brief description of electric drive for Hoe printing press, using storage battery for multi-voltage.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous Current Motors for Machine Tools."

#### A SERIES-PARALLEL SYSTEM OF SPEED CONTROL

Geo. W. Fowler

Vol. xx—1902, pp. 143-153

Description of controller and its mode of operation as applied to double commutator driving Webb press.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous Current Motors for Machine Tools."

#### CONTINUOUS-CURRENT MOTORS FOR MACHINE TOOLS

F. O. Blackwell

Vol. xx—1902, pp. 159-165

Power characteristics and requirements of various classes of machine tools. Brief mention of the different methods of speed control of electric motors and the advantages and limitations of each.

*Discussion* (including that of paper by R. T. E. Lozier on "The Operation of Machine Shops by Individual Electric Motors;" paper by N. W. Storer on "Three-Wire System for Variable Speed Motor Work;" paper by H. B. Coho on "The Storage Battery as a Factor in Speed Control;" paper by P. O. Keilholtz on "Electrically Operated Coal Hoist Having Variable Speed Control;" paper by Geo. W. Fowler on "A Series-Parallel System of Speed Control;" and paper by H. Ward Leonard on "Multiple-Unit, Voltage Speed Control for Trunk Line Service"), pp. 166-195, by Messrs. Gano S. Dunn, Chas. F. Scott, H. E. Heath, S. T. Dodd, Arthur Williams, Philip Lange, Chas. Day, R. T. E. Lozier, N. W. Storer, H. Ward Leonard, Herbert Dowe, H. B. Coho, Geo. A. Damon, R. W. Stovel, Geo. B. Dusinger, W. A. Dick, P. M. Lincoln, — Campbell, Chas. G. Winslow, E. M. Tingley, — Stevenson, — Barr, R. H. Pierce, Peter Junkersfeld, O. E. Osthoff, D. C. Jackson, B. J. Arnold, G. B. Foster, Ernest Gonzenbach, V. R. Lansingh, H. H. Cutler, F. J. Pearson, and H. R. King.

Relative merits of various methods of speed control of direct-current motors. Conditions which determine the choice between individual and group drive. Effects of motor drive and suitable speed control on shop efficiency. Advantages and disadvantages of the Ward-Leonard system of locomotive driven from single-phase circuits.

#### METHODS OF SPEED CONTROL

Wm. Cooper

Vol. xx—1902, pp. 197-213

Outline of the general power requirements of the different classes of machine tools. Description of method of choosing proper size of motor



for given service and speed range from a speed horse-power diagram for combining multiple voltage and field regulation; numerical examples. Set of general rules for determining motor size.

No discussion.

#### A NEW METHOD OF TURBINE CONTROL

Lamar Lyndon

Vol. xxv—1906, pp. 165-177

Theory and description of a water wheel governor designed to compensate pressure rises in pipe systems and to prevent overrunning.

*Discussion*, pp. 178-179, by Messrs. Paul Spencer, Lamar Lyndon and Carl Hering.

#### GAS-ENGINE REGULATION FOR DIRECT-CONNECTED UNITS

Charles E. Lucke

Vol. xxvi—1907, pp. 1-24

General discussion of speed regulation problems, defining the function of governors, fly-wheels and valve gears, and listing the variables that enter into the problem. The use of crank-pin force and speed diagrams, in the solution of such problems, is suggested and its application to steam turbine operation used as an illustration. A number of papers before the A. I. E. E. and A. S. M. E. on this subject are abstracted and commented upon.

No discussion.

#### REGENERATION OF POWER WITH SINGLE-PHASE ELECTRIC RAILWAY MOTORS

William Cooper

Vol. xxvi—1907, pp. 1469-1480

General requirements and motor characteristics necessary for successful regenerative control. Theory of regenerative control of single-phase series motors with examples of its practical applications.

*Discussion*, pp. 1481-1484, by Messrs. W. I. Slichter, L. B. Stillwell, J. C. Lincoln, and William Cooper.

Compounding effect utilized to improve power-factor of returned energy. Advantages of regenerative control.

#### ELECTRIC CONTROL FOR ROLLING MILL MOTORS

C. F. Henderson

Vol. xxviii—1909, pp. 897-912

Brief outline of essential requirements of controllers for motors operating ore handling machinery and rolling mills, with description of contactor type controller and various applications of automatic controllers in and about a steel mill.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

#### AUTOMATIC MOTOR CONTROL

H. E. White

Vol. xxviii—1909, pp. 913-920

Advantages and operative characteristics of contactor switch, and description of various systems of automatic control; current limit; counter e. m. f.; time limit, and pilot motor.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

## B. E. M. F. REGULATION

## A METHOD OF COMPOUNDING ALTERNATING-CURRENT GENERATORS AND MOTORS, DIRECT-CURRENT GENERATORS, SYNCHRONOUS MOTOR-GENERATORS AND SYNCHRONOUS CONVERTERS

Frank George Baum

Vol. xix—1902, pp. 745–757

Description of original methods of compounding alternating-current generators, synchronous motors, direct-current generators, synchronous converters, synchronous motor-generators and transmission systems. Use of the Baum regulation diagram.

*Discussion*, incorporated with that of paper by Chas. P. Steinmetz on "Notes on the Theory of the Synchronous Motor."

## THE DETERMINATION OF ALTERNATOR CHARACTERISTICS

Louis A. Herdt

Vol. xix—1902, pp. 1093–1121

Analytical and experimental study of alternator characteristics with description of different methods for determining regulation. Results of calculations checked with tests on inductor and revolving-field types of machines. Diagrams of the magnetic circuits of the machines tested, and many test curves of load and saturation characteristics, flux distribution, etc.

No discussion.

## THE EXPERIMENTAL BASIS FOR THE THEORY OF THE REGULATION OF ALTERNATORS

B. A. Behrend

Vol. xxi—1903, pp. 497–517

Experimental study of regulation of alternators indicating an approximate method of determining the regulation from the combination of the Behn-Eschenburg or e.m.f. method and the Institute or ampere-turn method.

## THE COMPOUNDING OF SELF-EXCITED ALTERNATING-CURRENT GENERATORS FOR VARIATION IN LOAD AND POWER-FACTOR

A. S. Garfield

Vol. xxi—1903, pp. 569–577

Description of the compounding and compensating characteristics of the Latour self-exciting alternator with brushes in different positions on both inductive and non-inductive loads.

*Discussion*, pp. 578–587, by Messrs. C. F. Scott, B. A. Behrend, C. A. Adams, Gano S. Dunn, W. L. Waters, J. R. Armstrong, Marius Latour, P. M. Lincoln, V. Karapetoff, — Schmit, J. S. Peck, and E. Molin.

General remarks on importance of specifying regulation and on methods of estimating it. Latour method of compounding alternators.

## AUTOMATIC APPARATUS FOR REGULATING GENERATOR AND FEEDER POTENTIALS

E. J. Bechtel

Vol. xxii—1903, pp. 741–745

Performance under service conditions of automatic direct-current and alternating-current generator e.m.f. regulator which operates by decreasing and increasing the field circuit resistance which changes in line e. m. f.

*Discussion*, incorporated with that of paper by W. C. L. Eglin on "Safeguards and Regulations in Operation of Overhead Distributing Systems."

**A CONTRIBUTION TO THE THEORY OF THE REGULATION OF ALTERNATORS**

H. M. Hobart and F. Punga

Vol. xxiii—1904, pp. 291-322

Theoretical investigation of armature reaction in singlephase and polyphase generator, development of method of calculating the regulation and excitation from the design constants of the machine. Actual tests of accuracy of the method in given instances. Complete design data given for the machines tested. Derivation of all new formulas.

*Discussion* (including that of paper by David B. Rushmore on "The Mechanical Construction of Revolving-Field Alternators"), pp. 323-343, by Messrs. C. A. Adams, Jr., B. A. Behrend, W. L. Waters, Gano S. Dunn, David B. Rushmore, F. A. C. Perrine, Bradley T. McCormick, V. Karapetoff, H. M. Hobart, and Franklin Punga.

Discussion of analytical and graphical methods of calculating exciting current and regulation from design data and experimental data.

**SYNCHRONOUS MOTORS FOR REGULATION OF POWER-FACTOR AND LINE PRESSURE**

B. G. Lamme

Vol. xxiii—1904, pp. 481-492

Discussion of factors which enter into the design of synchronous motor for power-factor regulation. Application of synchronous motors as regulators and as combined motor and regulator. General remarks on power-factor regulation, use of synchronous converters, cost of synchronous motor regulation, choice of location of regulator, etc.

*Discussion*, pp. 494-510, by Messrs. F. O. Blackwell, W. L. Waters, H. B. Gear, W. B. Jackson, F. A. C. Perrine, Ralph D. Mershon, S. B. Storer, Charles F. Scott, J. S. Peck, H. W. Buck, and T. J. Johnston.

General remarks on power-factor and e. m. f. regulation with synchronous motors. Description of methods of automatically adjusting the excitation of the synchronous motor.

**SOME DEVELOPMENTS IN SYNCHRONOUS CONVERTERS**

Chas. W. Stone

Vol. xxvii—1908, pp. 181-189

Description of some mechanical details of the vertical type synchronous converter. Brief discussion of the advantages and disadvantages of different methods of voltage regulation including the booster and the split-pole methods.

*Discussion*, incorporated with paper by J. E. Woodbridge on "Some Features of Railway Converter Design and Operation."

**ALTERNATING-CURRENT FEEDER REGULATORS**

W. S. Moody

Vol. xxvii—1908, pp. 255-272

Classification and brief discussion of the relative merits of different methods of feeder e. m. f.'s, followed by description of the construction and operative characteristics of the transformer and induction type regulators. A brief outline of the development of automatic control and description of applications of the Tirrill contact voltmeter to the control of feeder regulators.

*Discussion*, pp. 273-275, by Messrs. R. G. Black, J. Kynoch, and R. S. Kelsch.

Experience with the Tirrill and induction type regulators.

**VOLTAGE RATIO IN SYNCHRONOUS CONVERTERS WITH SPECIAL REFERENCE  
TO THE SPLIT-POLE CONVERTER**

Comfort A. Adams

Vol. xxvii—1908, pp. 959-985

Determination of e. m. f. wave form from the harmonic analysis of the flux distribution curve. The method is fully developed and then applied to two and three-part pole converters.

*Discussion*, incorporated with paper by J. L. Woodbridge on "Application of Storage Batteries to Regulation of Alternating-Current Systems."

**APPLICATION OF STORAGE BATTERIES TO REGULATION OF  
ALTERNATING-CURRENT SYSTEMS**

J. L. Woodbridge

Vol. xxvii—1908, pp. 987-1021

Brief general discussion of the various types of service where storage batteries can be used to regulate the alternating current load, including brief descriptions of some typical plants. Detailed description of the use of storage batteries with carbon regulator, split-pole converter and synchronous exciter, with analysis of performance. Analysis and oscillograms of e. m. f. waves of three-part and two-part pole converters. A general solution for the e. m. f. wave-form and two-part pole converter.

*Discussion* (including paper by Comfort A. Adams on "Voltage Ratio in Synchronous Converters, with Special Reference to the Split-Pole Converters"), pp. 1022-1055, by Messrs. P. M. Lincoln, A. S. Hubbard, W. L. Waters, Charles P. Steinmetz, J. L. Burnham, J. L. Woodbridge, and G. E. Brown.

General discussion of the performance characteristics of the split-pole converter, with physical exposition of the method of varying the voltage ratio and its effect on armature reaction, heating and commutation. Data from tests in commercial operation.

**CONDITIONS AFFECTING STABILITY IN ELECTRIC LIGHTING CIRCUITS**

Elihu Thomson

Vol. xxviii—1909, pp. 1-22

Historical resume of the development of arc lighting machines and systems. Characteristics of arc dynamos, constant-current transformers, mercury-arc converters, constant-current and constant-potential arc lamps with special reference to stability of operation.

*Discussion*, pp. 23-50, by Messrs. A. E. Kennelly, Alex Dow, E. W. Rice, Jr., Dugald C. Jackson, C. M. Green, John B. Taylor, H. G. Stott, Elihu Thomson, E. A. Sperry, and Charles P. Steinmetz.

Early experiences with arc lighting systems. Broad definition and examples of various kinds of electrical and mechanical instability. Permanent and transient volt-ampere characteristics of arcs.

**THE APPLICATION OF STORAGE BATTERIES TO THE REGULATION OF THE  
ALTERNATING-CURRENT LOAD AT THE PLANT OF THE  
INDIANA STEEL COMPANY, GARY, INDIANA**

J. Lester Woodbridge

Vol. xxviii—1909, pp. 851-866

Description, theory and results of batteries used in connection with

split-pole converters and synchronous exciters for regulation of alternating-current circuits.

*Discussion*, pp. 867-868, by Messrs. Edward Van Wagenen and J. L. Woodbridge.

Characteristics of synchronous exciter.

#### SOME PHASES OF TRANSFORMER REGULATION

W. A. Hillebrand and S. B. Charters, Jr.

Vol. xxviii—1909, pp. 1253-1267

Experimental study of effect of phase and voltage unbalance on transformer regulation, using different systems of connection.

*Discussion*, pp. 1268-1278, by Messrs. F. E. Giebel, W. F. Lamme, B. G. Lamme, J. W. White, S. G. Gassaway, C. L. Cory, F. V. T. Lee, H. C. Holberton, and W. A. Hillebrand.

General discussion of the effects of voltage unbalance on power apparatus and measuring instruments connected to transformers.

#### DETERMINATION OF TRANSFORMER REGULATION UNDER LOAD CONDITIONS AND SOME RESULTING INVESTIGATIONS

Adolph Shane

Vol. xxix—1910, pp. 1281-1294

Description of a method of measuring directly transformer regulation, also a method of direct determination of the transformer impedance triangle. Full account of tests made to establish the accuracy of the methods.

*Discussion*, pp. 1295-1302, by Messrs. Charles Fortescue, E. A. Wagner, L. T. Robinson, Ralph W. Atkinson, and Adolph Shane.

Objections to the author's methods. Modifications of the author's methods.

### C. SWITCHING

#### THE CONTROL OF HIGH POTENTIAL SYSTEMS OF LARGE POWER

E. W. Rice, Jr.

Vol. xviii—1901, pp. 407-420

Description of the type H oil switches designed for Metropolitan Traction Company and Manhattan Railway Company plants, together with short account of performance of oil, air and expulsion tube type switches under tests at high tension. General discussion of principles which should govern the layout of a central station.

*Discussion* (including that of paper by William S. Aldrich and George W. Redfield on "Performance of an Artificial Forty-Mile Transmission Line;" paper by F. A. C. Perrine on "Elements of Design, Particularly Pertaining to Long Distance Transmission;" paper by Charles F. Scott on "The Induction Motor and the Rotary Converter, and Their Relation to the Transmission System," and paper by Charles P. Steinmetz on "Theoretical Investigation of Some Oscillations of Extremely High Potential in Alternating-Current High Potential Transmissions"), pp. 421-442, and 667-669, by Messrs. Gano S. Dunn, George D. Shepardson, Henry W. Fisher, W. L. R. Emmett, A. E. Kennelly, Charles P. Stein-

metz, F. A. C. Perrine, L. B. Stillwell, Oberlin Smith, R. D. Mershon, Paul Janet, W. S. Aldrich, C. F. Scott, and Percy H. Thomas.

Relative advantages and comparative performance of induction motors and synchronous motors. Atmospheric losses at high tension lines as affected by diameter and stranding of conductor. Equation of rise of potential due to opening a circuit.

#### REVERSE-CURRENT CIRCUIT-BREAKERS AND THE PROTECTION OF TRANSMISSION LINES

Leonard Wilson

Vol. xxii—1903, pp. 303-309

General characteristics and principles of operation of reverse-power relays. Description of Andrews reverse-power indicator and differential choke coils for preventing the establishment of a reverse power.

*Discussion*, pp. 310-311, by Messrs. H. G. Stott, Leonard Wilson, and Charles F. Scott.

Method of using differential choke coils on any number of parallel feeders.

#### THE USE OF AUTOMATIC MEANS FOR DISCONNECTING DISABLED APPARATUS

H. G. Stott

Vol. xxii—1903, pp. 427-430

General recommendation for the protection of generators, transmission lines, synchronous converters and feeders, with reverse power and overload relays with and without time and current limit attachments.

*Discussion* (including that of paper by Henry W. Fisher on "Electric Cables for High Voltage Service" and paper by Philip Torchio on "The Operation and Maintenance of High-Tension Underground Systems"), pp. 431-444, by Messrs. W. F. Wells, Edward P. Burch, Carl Schwartz, W. G. Carlton, W. C. L. Eglin, C. O. Mailloux, Ralph D. Mershon, H. G. Stott, H. W. Fisher, W. L. Waters, R. S. Kelsch, and F. A. C. Perrine.

Experience in the operation of various large high-tension cable systems. General remarks on protection of transmission and distribution plants.

#### THE USE OF GROUP-SWITCHES IN LARGE POWER PLANTS

L. B. Stillwell

Vol. xxiii—1904, pp. 199-202

Wiring layout of Manhattan Railway power plant. Illustrating use of group switches, followed by classified advantages and disadvantages of group switches in this particular instance.

*Discussion*, pp. 204-214 and 238-242 and 247-249, by Messrs. Alex Dow, Ralph D. Mershon, H. G. Stott, Lewis B. Stillwell, William B. Jackson, Gilbert Wright, John B. Taylor, H. F. Parshall, W. G. Carlton, P. Junkersfeld, W. A. Blanck, G. N. Eastman, James Lyman, and B. P. Rowe.

General remarks pro and con the use of group switches. Various methods of connecting generators to feeders advocated. Method of clearing short circuit on long lines where power plants are operated in parallel.

## OIL SWITCHES FOR HIGH PRESSURES

E. M. Hewlett

Vol. xxiii—1904, pp. 215-216

Comparison of oil-break with air-break switches.

*Discussion*, pp. 217-224, and 242-245 and 249-251, by Messrs. C. C. Chesney, F. A. C. Perrine, Alex Dow, Ralph D. Mershon, C. F. Scott, P. N. Nunn, C. L. de Muralt, H. F. Parshall, W. W. Blanck, James Lyman, P. Junkersfeld, W. G. Carlton, E. O. Sessions, G. N. Eastman, I. E. Brooke, P. H. Thomas, R. F. Schuchardt, Edw. Schildhauer, H. F. Sanville, and W. C. L. Eglin.

Experience with oil switches in many large plants. Accounts of tests under short-circuit conditions. Specifications for oil switches and brief reference to some of the mechanical difficulties encountered with present types.

## TIME-LIMIT RELAYS

George F. Chellis

Vol. xxiv—1905, pp. 247-259

Classification of time-limit relays. Ideal requirements of relays for the protection of alternating-current generators, feeders and synchronous converters. Characteristic performance curves of relays under various conditions. Wiring diagrams for relay connections.

*Discussion*, incorporated with paper by H. W. Buck on "Duplication of Electrical Apparatus to Secure Reliability of Service."

## SWITCHBOARD PRACTICE FOR VOLTAGES OF 60,000 AND UPWARDS

Stephen Q. Hayes

Vol. xxvi—1907, pp. 1333-1357

Brief general discussion of factors which enter into the choice and arrangement of control apparatus in high-tension plants, with special reference to oil switches and circuit breakers. Designs for 60,000 and 100,000-volt stations given to demonstrate the relative space required.

*Discussion*, pp. 1358-1362, by Messrs. P. M. Lincoln, F. B. H. Paine, D. B. Rushmore, H. W. Buck, J. B. Taylor, William McClellan, W. N. Smith, L. C. Nicholson, S. Q. Hayes, J. H. Finney, F. G. Baum, and Ralph D. Mershon.

Use of extra line wire for emergency service. Method of tying conductors to pin type insulators.

## THE MODERN OIL SWITCH WITH SPECIAL REFERENCE TO SYSTEMS OF MODERATE VOLTAGE AND LARGE AMPERE CAPACITY

A. R. Cheney

Vol. xxix—1910, pp. 1091-1108

Analytical discussion of the present status of oil switch construction, pointing out lines along which future progress is apt to take place. Record of performance of 90 oil switches in actual service.

*Discussion*, pp. 1109-1124, by Messrs. Peter Junkersfeld, Ford W. Harris, C. W. Stone, D. B. Rushmore, C. P. Steinmetz, W. I. Donshea, V. Karapetoff, G. F. Sever, A. R. Cheney, and E. M. Hewlett.

General remarks on design and operation of oil switches. Experience in operation and results of experimental study.

## 17. TRACTION

### A. RAILWAY SYSTEMS

#### NOTES ON MODERN ELECTRIC RAILWAY PRACTICE

Albert H. Armstrong

Vol. xviii—1901, pp. 589-601

Consideration of the requirements of different classes of electric railway service leading up to a discussion of the relative merits of direct-current series and induction motors for interurban and trunk line operation.

*Discussion*, incorporated with that of paper by Ernst J. Berg on "Electric Railway Apparatus."

#### ELECTRIC RAILWAY APPARATUS

Ernst J. Berg

Vol. xviii—1901, pp. 603-630

Discussion of the characteristics and limitations of generators, converters, motor-generators and motors for different kinds of electric railway service. Extended consideration of the relative merits of direct-current series, and polyphase induction motors in a given numerical instance, comparing performance, efficiency and cost.

*Discussion* (including that of paper by Albert H. Armstrong on "Notes on Modern Electric Railway Practice"), pp. 631-666, by Paul Janet, Charles P. Steinmetz, G. Gillon, Charles Janisch, Bion J. Arnold, C. O. Mailloux, E. P. Roberts, L. B. Stillwell, A. H. Pott, C. F. Scott, P. K. Stern, H. C. Spaulding, F. S. Holmes, Ernst J. Berg, A. H. Armstrong, and N. C. Sawers.

General remarks on the stability of the induction motor for traction purposes.

#### SOME NOTES ON EUROPEAN PRACTICE IN ELECTRIC TRACTION WITH THREE-PHASE ALTERNATING CURRENTS

Carl L. DeMuralt

Vol. xix—1902, pp. 499-526

Development of polyphase traction system in Europe, with brief descriptions of the various roads that have been equipped with this system, and results of various tests showing the performance curves of the motors under actual service conditions.

*Discussion*, incorporated with that of paper by Ernst Danielson on "A Novel Combination of Polyphase Motors for Traction Purposes."

#### A NOVEL COMBINATION OF POLY-PHASE MOTORS FOR TRACTION PURPOSES

Ernst Danielson

Vol. xix—1902, pp. 527-539

Description of a system of concatenating two motors of unequal numbers of poles so as to get four running speeds. Comparison of acceleration characteristics, torque, energy, efficiency, etc., with direct-current series, plain induction and concatenated induction motors. Abstracted by Dr. Charles P. Steinmetz on page 495.



*Discussion* (including that of paper by Carl L. DeMuralt on "Some Notes on European Practice in Electric Traction With Three-Phase Alternating-Current"), pp. 540-555, by Messrs. C. P. Steinmetz, C. O. Mailloux, Henry G. Stott, W. N. Smith, W. J. Hammer, Townsend Wolcott, Frederick V. Henshaw, and C. L. DeMuralt.

#### NEW ELECTRO-PNEUMATIC SYSTEM OF ELECTRIC RAILWAY CONSTRUCTION

Bion J. Arnold

Vol. xix—1902, pp. 1003-1006

Announcement of the system and outline of its advantages.

*Discussion* (including that of paper by A. H. Armstrong on "A Study of the Heating of Railway Motors;" paper by B. J. Arnold and W. B. Potter on "Comparative Acceleration Tests With Steam Locomotive and Electric Motor Cars;" paper by B. J. Arnold on "Method of Accelerating by Means of a Dynamometer Car, the Power Required to Operate the Trains of the New York Central and Hudson River Railroad Company Between Mott Haven Junction and the Grand Central Station, and the Relative Cost of Operation by Steam and Electricity;" and paper by C. O. Mailloux on "Notes on the Plotting of Speed-Time Curves"), pp. 1007-1019, by Messrs. F. J. Sprague, F. S. Pearson, Oberlin Smith, S. T. Dodd, C. P. Steinmetz, H. Ward-Leonard, Harry Alexander, A. H. Armstrong, W. B. Potter, B. J. Arnold, and C. O. Mailloux. General remarks on the applications of electric motive power to steam railroads.

#### WASHINGTON, BALTIMORE & ANNAPOLIS SINGLE-PHASE RAILWAY

B. G. Lamme

Vol. xx—1902, pp. 15-30

Announcement of the first single-phase railway in the United States, with general description of the plant and discussion of the advantages of this system over the direct-current system.

*Discussion*, pp. 31-49, by Messrs. Charles P. Steinmetz, Ralph D. Mer-shon, W. E. Goldsborough, Bion J. Arnold, W. S. Franklin, Norman Rowe, C. O. Mailloux, Joseph Sachs, W. M. C. Gotshall, Herbert A. Wagner, Elias E. Ries, B. G. Lamme, P. K. Stern, C. F. Scott, and N. W. Storer.

Opinions as to the principal feature of the single-phase railway motor. Repulsion *vs.* series alternating-current motors.

#### MULTIPLE UNIT, VOLTAGE SPEED CONTROL FOR TRUNK LINE SERVICE

H. Ward Leonard

Vol. xx—1902, pp. 155-158

Enumeration of the essential features and advantages of the author's method of operating electric locomotives from single-phase distribution system.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous-Current Motors for Machine Tools."

## THE ALTERNATING-CURRENT RAILWAY MOTOR

Charles P. Steinmetz

Vol. xxiii—1904, pp. 9-25

Brief account of early work with compensated series commutator single-phase motor. Design data given for motors built by Eickemeyer and actual performance characteristics of this motor compared with calculated performance of repulsion motor. Analytical theory of single-phase repulsion motor.

*Discussion* (including that of paper by Walter I. Slichter on "Speed-Torque Characteristics of the Single-Phase Repulsion Motor"), pp. 26-81, by Messrs. B. G. Lamme, A. S. McAllister, B. J. Arnold, Charles P. Steinmetz, P. M. Lincoln, W. I. Slichter, Ralph D. Mershon, A. H. Armstrong, Robert Lundell, O. S. Lyford, Jr., H. A. Wagner, Charles F. Scott, B. A. Behrend, W. S. Franklin, Dugald C. Jackson, and V. Karapetoff.

Theory of operation of compensated series and repulsion motors treated analytically and graphically. Observed performance characteristics of repulsion motor as motor and as generator.

## SINGLE-PHASE RAILWAYS

W. A. Blanck

Vol. xxiii—1904, pp. 83-100

Brief mention of various types of motors that have been proposed for single-phase railways, followed by remarks on line construction for single-phase railways and detailed estimate of comparative cost of construction of 60-mile interurban road to operate respectively with direct-current and single-phase motor power.

No discussion.

## EFFECT OF SELF-INDUCTION ON RAILWAY MOTOR COMMUTATION

E. H. Anderson

Vol. xxiii—1904, pp. 379-391

Experimental study of commutation with oscillographic records of pressures between commutator segments under various conditions, and of potential rise in field and armature windings due to interruption and restoration of power at free running speeds.

*Discussion* (including that of paper by W. L. Waters on "Predetermination of Sparking in Direct-Current Machines"), pp. 443-457, by Messrs. W. L. Waters, E. R. Douglas, R. B. Treat, Thorburn Reid, E. H. Anderson, W. S. Franklin, Clarence P. Feldman, and H. Ward Leonard.

General remarks on commutation reaction and predetermination of the limitation of commutation.

## PRESIDENT'S ADDRESS

Bion J. Arnold

Vol. xxiii—1904, pp. 615-623

Brief sketch of electric railway development since 1893. Present prospects of electric locomotives supplanting steam locomotive. Dividing line between steam and electric trunk line operation.

*Discussion*, pp. 624-644, by Messrs. Charles P. Steinmetz, John Perry,

B. G. Lamme, C. V. Drysdale, B. J. Arnold, F. J. Sprague, and Elihu Thomson.

The requirements of different classes of railway service—city, suburban and interurban, passenger trunk line, freight trunk line, and mountain service. Speed-torque characteristics of various types of railway motors, single-phase, polyphase and direct-current, and discussion of proper spheres of application of the various motors. Development and application of single-phase compensated series motor. Methods of control. Invention of the repulsion motor.

#### PROBLEMS OF HEAVY ELECTRIC TRACTION

O. S. Lyford, Jr. and W. N. Smith

Vol. xxxiii—1904, pp. 691-722

Review of the considerations which enter into the problem of selecting the electric equipment for the Long Island Railroad. Account of tests made to check accuracy of train resistance formulas. Also tests with steam and electric trains.

*Discussion*, pp. 723-757, by Messrs. L. B. Stillwell, C. O. Mailloux, H. Ward Leonard, W. S. Franklin, A. H. Armstrong, C. T. Hutchinson, W. N. Smith, E. E. Ries, O. S. Lyford, Jr., and William McClellan.

General discussion of train resistance formulas, speed-time curves and the other factors which enter into the selection of motor equipment for trunk line operation. Comparison between speed-time and power-time curves for constant current per motor and constant current per car.

#### THREE-PHASE TRACTION

F. N. Waterman

Vol. xxiv—1905, pp. 465-509

Calculated performance of three-phase system with air gap and frequency of Valtellina line and other conditions the same as assumed by Mr. Berg in paper Vol. XVIII, 1901, page 603. Results compared with Mr. Berg's results for direct-current and three-phase systems with standard direct-current air-gap. Results of performance tests with Valtellina line: Comparison of dimensions and efficiencies of New York Central and Valtellina locomotive. Discussion of the inherent advantage of the three-phase system.

*Discussion*, pp. 510-523, by Messrs. F. N. Waterman, W. N. Smith, Charles P. Steinmetz, C. O. Mailloux, S. M. Kintner, H. G. Stott, and C. L. DeMuralt.

Disadvantages and advantages of the three-phase system of electric traction.

#### HEAVY TRACTION PROBLEMS IN ELECTRICAL ENGINEERING

Carl L. DeMuralt

Vol. xxiv—1905, pp. 525-552

Theoretical study of the comparative merits of three-phase and direct-current systems for heavy trunk line railroad service under definite assumed conditions, with tabulated results of all calculations.

*Discussion*, pp. 553-560, by Messrs. C. O. Mailloux, S. T. Dodd, F. N. Waterman, Charles P. Steinmetz, and C. L. DeMuralt.

General remarks on the performance characteristics of three-phase railway motor, with special reference to acceleration and recuperation of energy.

**WEIGHT DISTRIBUTION ON ELECTRIC LOCOMOTIVES AS AFFECTED BY  
MOTOR SUSPENSION AND DRAW-BAR PULL**

S. T. Dodd

Vol. xxiv—1905, pp. 591-607

Theoretical investigation of the weight distribution factor in various types of locomotive trucks, showing the effect of motor suspension, swivel trucks, pony trucks, etc., in the determination of tractive effort. Results of numerical examples given in tables.

*Discussion*, pp. 608-609, by Messrs. C. O. Mailloux, F. N. Waterman, and S. T. Dodd.

**LIGHT ELECTRIC RAILWAYS**

James R. Cravath

Vol. xxiv—1905, pp. 1067-1077

Description of a narrow gauge single-phase railway with light track construction suggested for rural transportation. Estimated first cost, operating expenses and gross earnings from freight and passenger traffic for location in central states.

No discussion.

**ON THE SUBSTITUTION OF THE ELECTRIC MOTOR FOR THE STEAM LOCOMOTIVE**

Lewis B. Stillwell and Henry St. Clair Putnam

Vol. xxvi—1907, pp. 31-101

Elaborate analysis of available data on actual cost of operation and maintenance of steam and electric railways. Estimated cost and saving incident to the electrification of all the steam roads in the United States with 11,000-volt single-phase system. Estimated power and energy consumption for average passenger and freight service on railroads of the United States. Importance of standardizing location of working conductor and frequency in electric railroad systems.

*Discussion*, pp. 102-161, by Messrs. Frank J. Sprague, B. G. Lamme, Bion J. Arnold, W. B. Potter, W. S. Murray, O. S. Lyford, Jr., C. L. DeMuralt, A. H. Armstrong, N. W. Storer, William McClellan, W. I. Slichter, J. B. Whitehead, L. B. Stillwell, Calvert Townley, Ralph D. Mershon, H. M. Brinckerhoff, A. H. Babcock, and Clarence Renshaw.

Lively discussion of the relative advantages of the direct-current, single-phase and three-phase systems for operation of railroads, with performance characteristics and operative data from different actual installations. Observed cost of fuel and steam locomotive repairs on the N. Y., N. H. & H. R. R. Numerous opinions as to best frequency for single-phase railway system.

## THE SINGLE-PHASE COMMUTATOR TYPE MOTOR

B. G. Lamme

Vol. xxvii—1907, pp. 137-156

Brief discussion of certain features in the design of compensated single-phase series motors for railway service; covering effects of magnetic induction and frequency in commutation and torque; decrease of effective air gap; effect of power-factor on overload torque, etc.

No discussion.

## HIGH-VOLTAGE DIRECT-CURRENT AND ALTERNATING-CURRENT SYSTEMS FOR INTERURBAN RAILWAYS

W. J. Davis, Jr.

Vol. xxvi—1907, pp. 387-392

Brief discussion of relative merits of 600-volt direct-current, 1,200-volt direct-current and 6,600-volt alternating-current systems for railway motor power, with estimated comparative first costs, operative costs, economy and other technical data.

*Discussion*, pp. 393-400, by Messrs. James Lyman, Mr. Hesing, Mr. Gould, W. J. Davis, Jr., Peter Junkersfeld, W. A. Blanck, T. F. Clohesey, L. M. Zapp, I. E. Brooke, H. R. King, Mr. Hatch, and E. N. Lake.

Additional information on the single-phase and 1,200-volt system.

## SOME FACTS AND PROBLEMS BEARING ON ELECTRIC TRUNK LINE OPERATION

Frank J. Sprague

Vol. xxvi—1907, pp. 681-772

General discussion of the problem of heavy railroad electrification, dwelling especially on the relative advantages of the direct-current and single-phase railway system. Comparison of different types of motors on basis of equal weights. Relative merits of various types of overhead and third-rail construction of direct-current, single-phase and three-phase motors, and of different types of locomotive running gears. Brief description of New York Central and New Haven locomotives. List of articles by author on subject of electric railways.

*Discussion*, pp. 773-812, by Messrs. W. J. Wilgus, Lewis B. Stillwell, W. B. Potter, Charles F. Scott, N. W. Storer, G. R. Henderson, William McClellan, A. H. Armstrong, C. P. Steinmetz, Frank J. Sprague, W. S. Murray, and T. J. Johnson.

Heated discussion of the relative merits of direct-current and single-phase methods of electric traction. Data on the comparative cost of the two systems.

## THE CHOICE OF FREQUENCY FOR SINGLE-PHASE ALTERNATING-CURRENT RAILWAY MOTORS

A. H. Armstrong

Vol. xxvi—1907, pp. 1377-1383

Brief general discussion of relative merits of 25 and 15 cycles in single-phase railway work, as regards motor equipment, coefficient of adhesion, generating and distributing apparatus.

*Discussion*, incorporated with paper by N. W. Storer on "Twenty-five versus Fifteen Cycles for Heavy Railways."

### TWENTY-FIVE VERSUS FIFTEEN CYCLES FOR HEAVY RAILWAYS

N. W. Storer

Vol. xxvi—1907, pp. 1385-1393

Brief general discussion of the relative advantages of 25 and 15 cycles in single-phase railway operation, with special reference to the effects on locomotive design and performance characteristics.

*Discussion* (including that of paper by A. H. Armstrong on "The Choice of Frequency for Single-phase Alternating-Current Railway Motors"), pp. 1394-1406, by Messrs. H. G. Reist, C. W. Stone, E. J. Berg, L. B. Stillwell, W. N. Smith, William McClellan, Charles P. Steinmetz, Peter Junkersfeld, Gano S. Dunn, Henry G. Stott, A. H. Armstrong, and N. W. Storer.

General remarks on the choice of frequency for single-phase railways. Most economical frequency for different apparatus employed in the system. Power required to handle steam railroad traffic entering Chicago.

### COMMUTATING-POLE DIRECT-CURRENT RAILWAY MOTORS

E. H. Anderson

Vol. xxvi—1907, pp. 1407-1417

Brief review of troubles encountered in the design of railway motors, leading up to commutation which is treated more in detail. Theory of action of commutating poles in series motor and possibilities as to voltage and service capacity which it introduces into direct-current railway engineering.

*Discussion*, pp. 1418-1419, by Messrs. Gano Dunn, J. C. Lincoln, E. H. Anderson, and W. N. Smith.

Flashing and creeping distances on 600-volt ordinary and 1,200-volt commutating pole railway motors.

### REGENERATION OF POWER WITH SINGLE-PHASE ELECTRIC RAILWAY MOTORS

William Cooper

Vol. xxvi—1907, pp. 1469-1480

General requirements and motor characteristics necessary for successful regenerative control. Theory of regenerative control of single-phase series motors with examples of its practical applications.

*Discussion*, pp. 1481-1484, by Messrs. W. I. Slichter, L. B. Stillwell, J. C. Lincoln, and William Cooper.

Compounding effect utilized to improve power factor of returned energy. Advantages of regenerative control.

### PRACTICAL ASPECTS OF STEAM RAILROAD ELECTRIFICATION

W. N. Smith

Vol. xxvi—1907, pp. 1693-1708

General discussion of steam railroad electrification from the standpoint of the steam railroad engineer and operator.

No discussion.

### A SINGLE-PHASE RAILWAY MOTOR

E. F. Alexanderson

Vol. xxvii—1908, pp. 1-17

Classification of single-phase railway motors, followed by theoretical analysis of the performance characteristics of series-repulsion motor.

*Discussion*, pp. 18-42, by Messrs. L. B. Stillwell, B. G. Lamme, W. B. Potter, O. S. Lyford, Jr., W. I. Slichter, S. N. Kintner, Charles P. Steinmetz, W. S. Murray, E. F. Alexanderson, and Elmer A. Sperry.

General remarks on the relative merits of series-repulsion and compensated series motors, with considerable data on the actual performance of the compensated series motor as to power-factor, commutation, brush wear, etc.

#### FROM STEAM TO ELECTRICITY ON A SINGLE-TRACK RAILROAD

J. B. Whitehead

Vol. xxvii—1908, pp. 1139-1168

Analytical study of the relative merits of 6,600-volt single-phase, and 600-volt direct-current system for a certain single-track railway line—covering calculation of impedance of distribution system; construction of speed, current and power-time curves, cost of construction, maintenance and operation. Actual cost of steam operation.

*Discussion*, pp. 1169-1175, by Messrs. J. B. Whitehead, W. I. Slichter, William McClellan, A. H. Babcock, A. W. Copley, Charles F. Scott, and S. H. Clarkson.

Results of actual tests on the constants of alternating-current railway circuits—impedance, resistance and reactance for trolley and rails on four, two and one-track roads.

#### THE LOG OF THE NEW HAVEN ELECTRIFICATION

W. S. Murray

Vol. xxvii—1908, pp. 1613-1664

Detailed account of the troubles encountered in the first four months' operation of the electric zone of the New Haven road, covering power plant (three-phase turbo-generators load on one phase) distribution system and locomotives. Complete tabular and graphical logs of delays, repairs, locomotive performance, etc., supplemented by measures to overcome the various difficulties encountered.

*Discussion*, pp. 1665-1719, by Messrs. L. A. Ferguson, Calvert Townley, B. G. Lamme, L. B. Stillwell, E. B. Katte, H. P. Davis, Charles P. Steinmetz, Philip Torchio, Minor M. Davis, B. A. Behrend, H. F. Parrshall, A. H. Armstrong, N. W. Storer, O. S. Lyford, Jr., W. N. Smith, Philip Dawson, Ivan Ofverholm, C. E. Eveleth, and W. S. Murray.

Additional information on the performance of the New Haven single-phase locomotives, the generators and the improved circuit breaking apparatus. Comparison of the New Haven single-phase locomotive and the New York Central direct-current locomotive. Operation experience with the single-phase line of the Erie Railroad. Overhead catenary construction of the London, Brighton and South Coast Railway.

#### ELECTRIC SYSTEM OF GREAT NORTHERN RAILWAY COMPANY AT CASCADE TUNNEL

Carly T. Hutchinson

Vol. xxviii—1909, pp. 1281-1319

Description of design, construction and operation of electrical equipment, with brief statement of the economies effected. Frictional resist-

ance of steam locomotives and tests of regenerative control of induction motors.

*Discussion*, pp. 1320-1359, by Messrs. L. B. Stillwell, Cary T. Hutchinson, W. S. Murray, E. B. Katte, Bion J. Arnold, F. N. Waterman, J. H. Davis, L. R. Pomeroy, W. N. Smith, F. S. Denneen, W. I. Slichter, E. F. W. Alexanderson, C. L. DeMuralt, Calvert Townley, Charles P. Steinmetz, Carl Schwartz, Frank J. Sprague, Edward P. Burch, Max Toltz, and E. Marshall.

General discussion of the relative merits of different systems of heavy electric traction, also of the economy and other advantages of electric over steam motive power. Additional description of the Great Northern system covering the overhead construction and the motor control and some of the difficulties in motor design.

**THE 1,200-VOLT RAILROAD—A STUDY OF ITS VALUE FOR INTERURBAN RAILWAYS**  
Charles E. Eveleth Vol. xxix—1910, pp. 1-14

Detailed estimate of the cost of construction, operation and maintenance of 1,200 and 600-volt direct-current interurban railways, based on four concrete applications.

*Discussion*, pp. 15-22, by Messrs. W. S. Murray, L. B. Stillwell, and C. E. Eveleth.

General remarks on the choice of system for interurban and other railroad lines.

**ON THE SPACE ECONOMY OF THE SINGLE-PHASE SERIES MOTOR**  
William S. Franklin and Stanley S. Seyfert Vol. xxix—1910, pp. 23-40

Theory and tests of a balanced choke coil arrangement for preventing excessive short-circuit currents due to pulsating flux; also description of a proposed single-phase commutator motor with external armature and commutator, intended to give improved utilization of space.

*Discussion*, pp. 41-53, by Messrs. S. M. Kintner, E. H. Anderson, E. F. W. Alexanderson, S. S. Seyfert, L. B. Stillwell, and W. S. Franklin.

Detailed criticism of the external armature type motor tending to show its impracticability. Brief mention of other methods of improving space economy. Weight and space factors from actual practice.

**THE DESIGN OF THE ELECTRIC LOCOMOTIVE**  
N. W. Storer and G. M. Eaton Vol. xxix—1910, pp. 1415-1439

General discussion of some of the mechanical features in the design of electric locomotives, with special reference to the mode of mounting the motors and of coupling them to the driving wheels. Requirements of different classes of railroad service. Relation of height of center of gravity to lateral track disturbances.

*Discussion*, pp. 1440-1459, by Messrs. William McClellan, A. F. Batch-



elder, Frank J. Sprague, A. H. Armstrong, G. M. Eaton, N. W. Storer, and Elmer A. Sperry.

General remarks on the design of running gear for electric locomotives, with expression of opinion on the effect of height of center of gravity on the track. Tests on separately driven and coupled drivers.

## B. TRAIN MOVEMENT AND MOTOR CAPACITY

### THE RELATION OF ENERGY AND MOTOR CAPACITY TO SCHEDULE SPEED IN THE MOVING OF TRAINS BY ELECTRICITY

Cary T. Hutchinson

Vol. xix—1902, pp. 129-164

Analytical and graphical investigation of ideal speed-time curves, showing the effect of varying acceleration on size of motor, energy consumption and total economy of operation. Methods of calculation fully explained by use of numerical examples.

*Discussion*, incorporated with that of paper by W. B. Potter on "The Selection of Electric Motors for Railway Service."

### A CONSIDERATION OF THE INERTIA OF THE ROTATING PARTS OF A TRAIN

Norman Wilson Storer

Vol. xix—1902, pp. 165-168

The equivalent inertia, weight of wheels and motors—its magnitude; effect of change of gear ratio and simple methods of including it in train performance calculations.

*Discussion*, incorporated with that of paper by W. B. Potter on "The Selection of Electric Motors for Railway Service."

### THE SELECTION OF ELECTRIC MOTORS FOR RAILWAY SERVICE

W. B. Potter

Vol. xix—1902, pp. 169-177

Discussion of the various factors which enter into the determination of the size of motor required for a given service—gear ratio, losses and their distribution, etc. Table based on service tests showing the schedule speeds for different gear ratios, stops per mile and tons per motor for a given motor.

*Discussion* (including that of paper by Cary T. Hutchinson on "The Relation of Energy and Motor Capacity to Schedule Speed in Moving of Trains by Electricity;" and paper by Norman Wilson Storer on "A Consideration of the Inertia of the Rotating Parts of a Train"), pp. 178-182, by Messrs. W. C. Gotshall, M. H. Gerry, Jr., Philip Torchio, H. G. Stott, Charles P. Steinmetz, S. T. Dodd, P. O. Keilholtz, Louis Duncan, and Cary T. Hutchinson. Sharp criticisms of Dr. Hutchinson's paper. Detailed criticisms of Dr. Hutchinson's assumptions and conclusions by comparison with calculations made for the New York & Portchester Railroad. Use of Dr. Hutchinson's formulas in definite problem, comparing results with those obtained by usual methods.

## A STUDY OF THE HEATING OF RAILWAY MOTORS

A. H. Armstrong

Vol. xix—1902, pp. 809-832

Outline of method of determining probable heating and energy consumption of given equipment for any class of work based on actual experiments.

*Discussion*, incorporated with that of paper by Bion J. Arnold on "New Electro-Pneumatic System of Electric Railway Construction."

COMPARATIVE ACCELERATION TESTS WITH STEAM LOCOMOTIVE, AND  
ELECTRIC MOTOR CARS

B. J. Arnold and W. B. Potter

Vol. xix—1902, pp. 833-850

Description and average results of tests carried out by the authors in preparing report on the use of electricity for the propulsion of trains of the New York Central Railroad. Comparative performance of steam and electric engines under frequent-stop suburban service, with results of tests plotted as curves and arranged in tables giving the energy and power consumption, maximum acceleration utilization of weight on drivers, energy efficiency, coal consumption, etc.

*Discussion*, incorporated with that of paper by B. J. Arnold on "New Electro-Pneumatic System of Electric Railway Construction."

METHOD OF ASCERTAINING BY MEANS OF A DYNAMOMETER CAR THE POWER  
REQUIRED TO OPERATE THE TRAINS OF THE NEW YORK CENTRAL AND  
HUDSON RIVER RAILROAD BETWEEN MOTT HAVEN JUNCTION AND  
GRAND CENTRAL STATION, AND THE RELATIVE COST OF  
OPERATION BY STEAM AND ELECTRICITY

Bion J. Arnold

Vol. xix—1902, pp. 865-899

Description of the dynamometer car and its mode of operation. Curve records of tests. Tabulated results and discussion of the method of working up the data. Comparative fixed and operating costs for steam and electric motive power.

*Discussion*, incorporated with that of B. J. Arnold on "New Electro-Pneumatic System of Electric Railway Construction."

## NOTES ON THE PLOTTING OF SPEED-TIME CURVES

C. O. Mailloux

Vol. xix—1902, pp. 901-1001

Detailed analytical study of methods of calculating and plotting speed-time curves for determining motor capacity required for a given service. Accurate graphical method proposed. Charts of coefficients for use in plotting speed-time curves. Numerical examples of the calculation and plotting of speed-time, and distance-time curves for service runs. All formulas developed and rigorously proved.

*Discussion*, incorporated with that of paper by B. J. Arnold on "New Electro-Pneumatic System of Electric Railway Construction."

## BRAKING AND TRACTION BRAKES

Introduction by President Charles F. Scott.

Vol. xx—1902, pp. 215-217

## SOME BRAKE TESTS AND DEDUCTIONS THEREFROM

J. D. Keiley

Vol. xx—1902, pp. 219-233

A description of a method of making brake tests and of a manual recording apparatus used in this method; also results from tests on a number of varieties of brakes and an empirical equation showing the operation of these brakes under different conditions, the coefficients entering into the equation being derived from the tests.

## RAILROAD CAR BRAKING

R. A. Parke

Vol. xx—1902, pp. 235-275

Brief sketch of development of power brakes. Analysis of Westinghouse-Galton braking tests, giving equations for the coefficients of friction under various conditions. Outline of the requirements and limitations of high-speed braking. Analytical study of the distribution of forces in car brakes acted on by retarding force, showing loss of efficacy occasioned by re-distribution of weight, followed by description of a method of brake rigging construction to compensate this loss. Equations for determining maximum braking force under various conditions. Description of construction and mode of operation of the magnetic traction brake.

*Discussion*, pp. 276-300, by Messrs. H. G. Stott, C. O. Mailloux, O. S. Lyford, Jr., Calvert Townley, W. O. Gotshall, R. A. Parke, Elias E. Ries, W. N. Smith, W. J. Hammer, W. S. Franklin, William Esty, H. H. Westinghouse, F. C. Newell, N. W. Storer, Calvin W. Rice, Charles F. Scott B. J. Arnold, T. P. Gaylord, J. R. Cravath, R. H. Pierce, and Eugene B. Clark.

General remarks on high-speed power braking and the possibilities of predetermining braking performance. General results of actual tests. Characteristics and performance of the magnetic traction brake. Historical notes on magnetic, eddy-current and hysteresis brakes.

## HIGH-SPEED ELECTRIC RAILWAY PROBLEMS

A. H. Armstrong

Vol. xxii—1903, pp. 91-108

Development of graphical charts for calculation of interurban motive power problems—relations between schedule speeds, maximum speed and stops per mile; between motor rating, schedule speed and tons per mile; schedule speed and average consumption. Numerical example showing the relative cost and economy of one-car and two-car operation, solved by use of the charts.

No discussion.

## PREDETERMINATION IN RAILWAY WORK

F. W. Carter

Vol. xxii—1903, pp. 133-164

Development of a system of simple equations which permit the rapid calculation of train performance and the determination of motor capacity for a given service. Charts given for facilitating calculations of speed-

time, speed-distance and time-distance curves. Numerical examples illustrating the use of charts and formulas.

*Discussion*, pp. 165-174, by Mr. C. O. Mailloux.

Comparison of Mailloux's method with that of the author. Development of general equations for solution of train movement problems.

#### INTERURBAN CAR TESTS

W. E. Goldsborough and P. E. Fansler

Vol. xxii—1903, pp. 175-221

Description and results of tests on interurban lines of Indiana Union Traction Company's system, covering energy and power consumption for different kinds of service, and effect of personality of motorman thereon. Special service capacity tests on different types of equipment. Data presented in form of tables and formulas.

*Discussion*, pp. 222-230, by Messrs. E. P. Roberts and I. H. Sherwood, and A. H. Armstrong.

Description and results of tests of passenger car, limited car, express car and two-car train on lines of Northern Texas Traction Company; power and energy consumption.

#### SOME NOTES ON THE OPERATION OF RAILWAY MOTORS IN SERVICE

Clarence Renshaw

Vol. xxii—1903, pp. 279-297

Consideration of factors which limit safe load on railway motors. Discussion of characteristics of service loads and losses and method of producing equivalent loads. Description of tests on city car in actual service with results plotted on graphic charts.

*Discussion* (including that of paper by W. E. Goldsborough and P. E. Fansler on "The Storage Battery in Sub-stations"), pp. 298-302, by Messrs. Cary T. Hutchinson, H. G. Stott, W. E. Goldsborough, and A. H. Armstrong.

Predetermination of temperature rise of railway motors by Hutchinson method. Value of storage battery in railway sub-stations. Arguments against square root of mean square current method of determining motor capacity.

#### THE CONDITIONS GOVERNING THE RISE OF TEMPERATURE OF ELECTRIC RAILWAY MOTORS IN SERVICE

Cary T. Hutchinson

Vol. xxii—1903, pp. 657-679

Development of a method of obtaining for a given schedule and for a given temperature rise, the size of the motor in horse-power per ton, the energy input and the critical acceleration for any motor, taking as data the  $I^2R$  and the core losses of the motor and radiation coefficients determined by actual tests under service conditions. Sets of curves for facilitating calculations and examples illustrating their use.

*Discussion*, pp. 680-687, by Messrs. A. H. Armstrong, Cary T. Hutchinson, and Louis Duncan.

Limitations imposed by author's assumptions. Demonstration of the accuracy of the method for general application.

**PROBLEMS OF HEAVY ELECTRIC TRACTION**

O. S. Lyford, Jr., and W. N. Smith Vol. xxiii—1904 pp. 691-722

Review of the considerations which entered into the problem of selecting the electric equipment for the Long Island Railroad. Account of tests made to check accuracy of train resistance formulas. Also tests with steam and electric trains.

*Discussion*, pp. 723-757, by Messrs. L. B. Stillwell, C. O. Mailloux, H. Ward Leonard, W. S. Franklin, A. H. Armstrong, C. T. Hutchinson, W. N. Smith, E. E. Ries, O. S. Lyford, Jr., and William McClellan.

General discussion of train resistance formulas, speed-time curves and the other factors which enter into the selection of motor equipment for trunk line operation. Comparison between speed-time and power-time curves for constant current per motor and constant current per car.

**TWO-MOTOR VERSUS FOUR-MOTOR EQUIPMENTS**

N. McD. Crawford Vol. xxiv—1905, pp. 65-75

Tests with four cars under equal conditions in city service, giving energy consumption per ton mile and per passenger and other operation data.

*Discussion*, pp. 76-80, by Messrs. N. McD. Crawford, A. H. Armstrong, S. T. Dodd, and Calvert Townley.

General remarks on four-motor versus two-motor car equipments.

**CHOICE OF MOTORS IN STEAM AND ELECTRIC PRACTICE**

William McClellan Vol. xxiv—1905, pp. 561-572

Tabulated technical data on steam locomotives for local, express and freight service on principal roads in North America, giving type, dimensions, weights, fuel, tractive efforts, loads, road profile, etc. Discussion of characteristic features of steam and electric motive power and desirability of standardizing electric locomotives.

*Discussion*, pp. 573-576, by Messrs. W. E. Goldsborough, C. O. Mailloux, Charles P. Steinmetz, and H. G. Stott.

Practical difficulties of standardization.

**INERURBAN TEST CAR OF THE UNIVERSITY OF ILLINOIS**

Thomas M. Gardner Vol. xxv—1906, pp. 507-517

Description of the car and its equipment, with special reference to a method of measuring acceleration directly with a voltmeter.

*Discussion*, page 518, by Messrs. P. M. Lincoln, D. C. Jackson, and M. K. Akers.

**COMPARATIVE PERFORMANCE OF STEAM AND ELECTRIC LOCOMOTIVES**

Albert H. Armstrong Vol. xxvi—1907, pp. 1643-1674

General discussion of the relative merits of direct-current and alternating-current electric locomotives and simple and compound steam locomotives, with special reference to capacity and cost of operation. Performance characteristic curves for steam and electric machines. Results of

tests of actual fuel consumption of steam locomotives on mountain grades.

*Discussion*, pp. 1675-1691, by Messrs. William J. Wilgus, Cary T. Hutchinson, W. S. Murray, William McClellan, C. L. deMuralt, W. N. Smith, Charles P. Steinmetz, and A. H. Armstrong.

Actual savings and increase in capacity attained with New York Central terminal electrification. Comparison of Mallet compound with electric locomotive. Tests of fuel consumption of steam locomotives in express, local and freight traffic on New Haven road. Comparative cost of increasing number of tracks and electrification.

#### FROM STEAM TO ELECTRICITY ON A SINGLE-TRACK RAILROAD

J. B. Whitehead

Vol. xxvii—1908, pp. 1139-1168

Analytical study of the relative merits of 6,600-volt single-phase, and 600-volt direct-current system for a certain single-track railway line—covering calculation of impedance of distribution system; construction of speed, current and power-time curves, cost of construction, maintenance and operation. Actual cost of steam operation.

*Discussion*, pp. 1169-1175, by Messrs. J. B. Whitehead, W. I. Slichter, William McClellan, A. H. Babcock, A. W. Copley, Charles F. Scott, and S. H. Clarkson.

Results of actual tests on the constants of alternating-current railway circuits—impedance, resistance and reactance for trolley and rails on four, two and one-track roads.

#### POWER ECONOMY IN ELECTRIC RAILWAY OPERATION—COASTING TESTS ON THE MANHATTAN RAILWAY, NEW YORK

H. St. Clair Putnam

Vol. xxix—1910, pp. 1461-1485

Analytical study of the relations between coasting time and acceleration, braking and time of stop, showing how, for a given schedule, the coasting time constitutes a direct measure of the saving of energy, the calculated results being checked by tests made with a coasting clock. Record of actual operation with coasting clock on a large scale, showing its effect on the efficiency of the motorman.

*Discussion*, pp. 1486-1494, by Messrs. John B. Taylor, A. H. Armstrong, N. W. Storer, William McClellan, L. B. Stillwell, Frank J. Sprague, G. H. Hill, H. St. Clair Putnam, and P. A. Bancel.

General remarks on the methods of saving energy by using automatic acceleration or retardation, and examples showing saving due to use of grades into and out of stations.

#### A METHOD FOR DETERMINING THE ADEQUACY OF AN ELECTRIC RAILWAY SYSTEM

R. W. Harris

Vol. xxix—1910, pp. 1495-1516

Description of methods of determining the amount and quality of service furnished by a city street railway, with results of investigations in Milwaukee and other large cities, covering the movements and habits of people, headways, delays, time of stops, etc.

No discussion.

## C. DISTRIBUTION CIRCUITS

SOME RECOMMENDATIONS CONCERNING ELECTRICAL AND MECHANICAL  
SPECIFICATIONS OF TROLLEY INSULATORS

Samuel Sheldon and John D. Keiley

Vol. xxii—1903, pp. 231-239

Description of methods and results of testing strain insulators for tensile strength, breakdown e. m. f., insulation resistance and determination of maximum working temperature for round top trolley suspension insulators. Specifications for various forms of insulators for overhead trolley construction.

*Discussion*, pp. 240-242, by Messrs. Joseph Sachs, Ralph D. Mershon, and Samuel Sheldon.

Recommendations for standard railway insulator specifications. A. c. vs. d. c. for testing insulators for use on d. c. circuits.

## ON THE CALCULATION OF LINE BATTERIES

W. E. Winship

Vol. xxiii—1904, pp. 393-402

Outline of method of determining the size and location of battery floating on railway distribution system under various conditions of service.

*Discussion*, pp. 457-459, by Messrs. F. J. White, Lamar Lyndon, and W. E. Winship.

Practical importance of battery resistance in calculation of line batteries.

## ON TRACK BONDING

C. W. Ricker

Vol. xxiv—1905, pp. 81-92

Classification of rail bonds. General remarks on inspection, failure and installation of bonds. Actual costs of installation and tests on the resistance of bonded joints after several years of service.

*Discussion*, pp. 93-96, by Messrs. C. W. Ricker, H. A. Lardner, A. A. Knudson, William Pestell, Calvert Townley, and Ralph D. Mershon.

Calculation of most economical cross section of bonds. General remarks on installation of bonds, their deterioration and the measurement of contact resistance.

## LINE CONSTRUCTION FOR HIGH-PRESSURE ELECTRIC RAILROADS

George A. Damon

Vol. xxiv—1905, pp. 97-121

Description of high-tension overhead trolley construction in Europe and United States, illustrated by numerous detail drawings. Description of Huber system of current collection. General conclusions regarding standard trolley voltage, standard location of working condition and type of construction for high-voltage work on interurban and trunk lines.

*Discussion*, incorporated with paper by Theodore Varney on "High-Pressure Line Construction for Alternating-Current Railways."

**HIGH-PRESSURE LINE CONSTRUCTION FOR ALTERNATING-CURRENT RAILWAYS**  
Theodore Varney

Vol. xxiv—1905, pp. 123-142

Profusely illustrated description of overhead catenary construction used in United States, with proposed general plan for high-tension overhead construction based on one year's experience with single catenary in Indiana.

*Discussion* (including that of paper by George A. Damon on "Line Construction for High-Pressure Electric Railroads"), pp. 143-163, by Messrs. J. W. Lieb, Jr., F. N. Waterman, Calvert Townley, A. H. Armstrong, A. H. Babcock, C. O. Mailloux, Theodore Varney, and George F. Sever.

General remarks on the merits and limitations of high-trolley voltage. Experience of Ganz & Company with alternating-current trolley construction. Detailed description with illustrations of the Huber trolley system.

**SHUNT AND COMPOUND-WOUND SYNCHRONOUS CONVERTERS FOR RAILWAY WORK**  
W. L. Waters

Vol. xxv—1906, pp. 549-553

Some advantages and disadvantages of compound-wound synchronous converters.

*Discussion*, pp. 554-557, by Messrs. J. B. Taylor, P. M. Lincoln, and W. L. Waters.

General remarks pro and con compound-wound synchronous converters.

**ALTERNATING-CURRENT ELECTROLYSIS**

J. L. R. Hayden

Vol. xxvi—1907, pp. 201-229

Experimental investigation of alternating-current electrolysis and chemical corrosion—tests with lead plates and various salt solutions with varying frequency and current density; tests with different soils and salt solutions in soil. Electrical method of protecting lead cable sheaths.

*Discussion*, incorporated with paper by George I. Rhodes on "Some Theoretical Notes on the Reduction of Earth Currents From Electric Railway Systems by Means of Negative Feeders."

**ELECTROLYTIC CORROSION OF IRON AND STEEL IN CONCRETE**

A. A. Knudson

Vol. xxvi—1907, pp. 231-246

An account of laboratory tests on structural steel embedded in concrete and subjected to a constant current. General conclusions as to electrolysis of bridge and building foundations and remedies therefor.

*Discussion*, incorporated with paper by George I. Rhodes on "Some Theoretical Notes on the Reduction of Earth Currents From Electric Railway Systems by Means of Negative Feeders."



**SOME THEORETICAL NOTES ON THE REDUCTION OF EARTH CURRENTS FROM  
ELECTRIC RAILWAY SYSTEMS BY MEANS OF NEGATIVE FEEDERS**

George I. Rhodes

Vol. xxvi—1907, pp. 247-263

Mathematical and theoretical investigation of the relative efficiency of different return feeder systems in reducing stray currents. Equations for all quantities and graphical charts showing potential distribution and relative earth currents for different systems of return feeders.

*Discussion* (including that of paper by J. L. R. Hayden on "Alternating-Current Electrolysis" and paper by A. A. Knudson on "Electrolysis Corrosion of Iron and Steel in Concrete"), pp. 264-302, by Messrs. L. B. Stillwell, Frank N. Waterman, Paul Winsor, J. W. Corning, S. M. Kintner, Calvert Townley, George F. Sever, Albert F. Ganz, C. P. Steinmetz, J. L. R. Hayden, Philip Torchio, A. M. Schoen, W. R. C. Corson, F. A. C. Perrine, A. A. Knudson, H. W. Fisher, and R. A. L. Snyder.

General discussion of electrolysis. Experience with three-wire railway distribution system in Boston. Results of tests for alternating-current electrolysis. Protection of lead covered cables.

**MOTOR GENERATORS VS. SYNCHRONOUS CONVERTERS**

P. M. Lincoln

Vol. xxvi—1907, pp. 303-311

Brief general analysis of the relative merits of synchronous converters, synchronous motor-generators and induction motor-generators from operative and economical standpoints.

*Discussion*, pp. 312-349, by Messrs. A. H. Armstrong, W. L. Waters, H. G. Stott, Ralph D. Mershon, Charles W. Stone, Charles F. Scott, Philip Torchio, B. A. Behrend, J. R. C. Armstrong, A. H. Babcock, F. G. Baum, Ernst J. Berg, R. G. Black, Edward P. Burch, H. W. Buck, O. B. Coldwell, W. R. C. Corson, Henry Floy, Clarence E. Gifford, William B. Jackson, R. S. Kelsch, Farley Osgood, John C. Parker, H. F. Parshall, A. C. Pratt, Leo Schuler, Carl Schwartz, Guido Semenza, B. C. Shipman, Miles Walker, and J. B. Whitehead.

General discussion of the relative merits of the synchronous converter, the synchronous motor-generator and the induction motor-generator with regard to reliability, voltage regulation, efficiency, cost, etc.

**SINGLE-PHASE VS. THREE-PHASE GENERATION FOR SINGLE-PHASE RAILWAYS**

A. H. Armstrong

Vol. xxvi—1907, pp. 1367-1372

Brief discussion of the relative merits of different systems of deriving a single-phase railway distribution circuit from single-phase, three-phase and two-phase generators.

*Discussion*, pp. 1373-1376, by Messrs. P. M. Lincoln, Henry G. Stott, V. Karapetoff, John B. Taylor, William McClellan, Charles P. Steinmetz, and A. H. Armstrong.

Suggested remedies for distortion of three-phase system caused by single-phase load.

**THE NEW HAVEN SYSTEM OF SINGLE-PHASE DISTRIBUTION WITH SPECIAL  
REFERENCE TO SECTIONALIZATION**

W. S. Murray

Vol. xxvii—1908, pp. 43-55

Classification of single-phase railway distribution, followed by a discussion of the advantages and disadvantages of the system used by the N. Y., N. H. & H. Railroad, with results of experience gained during six months of actual operation.

*Discussion*, pp. 56-65, by Messrs. W. S. Murray, L. B. Stillwell, W. B. Potter, and O. S. Lyford, Jr.

Additional data on the New Haven system; also very brief general description of the distribution system used on single track, single-phase railroads (Erie R. R. and Denver & Interurban R. R.).

**SOME DEVELOPMENTS IN SYNCHRONOUS CONVERTERS**

Chas. W. Stone

Vol. xxvii 1908, pp. 181-189

Description of some mechanical details of the vertical type synchronous converter. Brief discussion of the advantages and disadvantages of different methods of voltage regulation including the booster and the split-pole methods.

*Discussion*, incorporated with paper by J. E. Woodbridge on "Some Features of Railway Converter Design and Operation."

**SOME FEATURES OF SYNCHRONOUS CONVERTER DESIGN AND OPERATION**

J. E. Woodbridge

Vol. xxvii—1908, pp. 191-216

Analytical study of the three-phase and the six-phase synchronous converter, with a demonstration of the advantages of the self starting converters and a discussion of the theory and practice of compounding.

*Discussion* (included with the paper by W. L. Waters on "The Non-Synchronous Generator in Central Station and Other Work," and paper by Charles W. Stone on "Some Developments in Synchronous Converters"), pp. 217-254, by Messrs. C. F. Scott, Paul M. Lincoln, F. G. Clark, Charles P. Steinmetz, Comfort A. Adams, J. R. Bibbins, Philip Torchio, J. B. Taylor, W. L. Waters, J. E. Woodbridge, and C. W. Stone.

General discussion of the advantages and disadvantages of the induction generator from the operating standpoint. Split-pole *vs.* alternating-current booster methods of e. m. f. regulation for converters.

**FROM STEAM TO ELECTRICITY ON A SINGLE-TRACK RAILROAD**

J. B. Whitehead

Vol. xxvii—1908, pp. 1139-1168

Analytical study of the relative merits of 6,600-volt single-phase, and 600-volt direct-current system for a certain single-track railway line—covering calculation of impedance of distribution system; construction of speed-current and power-time curves; cost of construction, maintenance and operation. Actual cost of steam operation.

*Discussion*, pp. 1169-1175, by Messrs. J. B. Whitehead, W. I. Slichter,

William McClellan, A. H. Babcock, A. W. Copley, Charles F. Scott, and S. H. Clarkson.

Results of actual tests on the constants of alternating current railway circuits—impedance, resistance and reactance for trolley and rails on four, two and one-track roads.

#### CONDUCTOR RAIL MEASUREMENTS

S. B. Fortenbaugh

Vol. xxvii—1908, pp. 1215-1229

Results of tests on Metropolitan District Railway third and fourth rail conductors, giving leakage and insulation difficulties under various conditions of service; also complete data on resistance tests made on conductor rails.

No discussion.

#### EVEN HARMONICS IN ALTERNATING-CURRENT CIRCUITS

John B. Taylor

Vol. xxviii—1909, pp. 725-732

Description of conditions under which even harmonics may be produced in commercial circuits, with special reference to the effect of stray direct-current on the performance of stationary transformers. Tests and oscillograms of transformer exciting current with stray direct current in the windings.

*Discussion*, pp. 773-736, by Messrs. Frederick Bedell, V. Karapetoff, Charles F. Scott, Charles P. Steinmetz, and John B. Taylor.

Production of even harmonics in alternators and effect of direct current in the windings of a transformer upon the losses.

#### ELECTRIC SYSTEM OF GREAT NORTHERN RAILWAY COMPANY AT CASCADE TUNNEL

Cary T. Hutchinson

Vol. xxviii—1909, pp. 1281-1319

Description of design, construction, and operation of electrical equipment, with brief statement of the economies affected. Frictional resistance of steam locomotives and tests of regenerative control of induction motors.

*Discussion*, pp. 1320-1359, by Messrs. L. B. Stillwell, Cary T. Hutchinson, W. S. Murray, E. B. Katte, Bion J. Arnold, F. N. Waterman, J. H. Davis, L. R. Pomeroy, W. N. Smith, F. S. Denneen, W. I. Slichter, E. F. W. Alexanderson, C. L. deMuralt, Calvert Townley, Charles P. Steinmetz, Carl Schwartz, Frank J. Sprague, Edward P. Burch, Max Toltz, and E. Marshall.

General discussion of the relative merits of different systems of heavy electric traction, also of the economy and other advantages of electric over steam motive power. Additional description of the Great Northern System covering the overhead construction and the motor control and some of the difficulties in motor design.

## THE APPLICATION OF PORCELAIN TO STRAIN INSULATORS

W. H. Kempton

Vol. xxix—1910, pp. 967-974

Brief account of tests on several different types of strain insulators, giving the ultimate shearing, tensile and compressive stresses.

*Discussion*, incorporated with that of paper by W. N. Smith on "Electric Railway Catenary Trolley Construction."

## ELECTRIC RAILWAY CATENARY TROLLEY CONSTRUCTION

W. N. Smith

Vol. xxix—1910, pp. 975-1010

Review and discussion of current practice in catenary trolley construction, with design data and many illustrations of practical types of construction.

*Discussion* (including that of W. H. Kempton's paper on "Application of Porcelain to Strain Insulators"), pp. 1011-1036, by Messrs. Percy H. Thomas, C. J. Hixon, R. D. Coombs, R. C. Thurston, Charles R. Harte, Ralph D. Mershon, O. S. Lyford, Jr., W. H. Kempton, W. N. Smith, and Edwin B. Katte.

Remarks on properties of porcelain and design of strain insulators. Specifications for N. Y. C. R. R. high and low-tension strain insulators. Accounts of experiments and experience with catenary construction and current collectors of different types.

## INTERPOLES IN SYNCHRONOUS CONVERTERS

B. G. Lamme and F. D. Newbury

Vol. xxix—1910, pp. 1625-1653

Analytical discussion of commutation in direct-current generators and synchronous converters, with reference to the advantages and disadvantages of commutating poles. General summary of the factors that limit the economical output of various types of converters.

*Discussion*, pp. 1654-1678, by Messrs. Gano Dunn, H. F. T. Erben, C. P. Steinmetz, Jens Bache-Wiig, P. M. Lincoln, J. L. Burnham, C. W. Stone, C. A. Adams, and B. G. Lamme.

General remarks on the use of commutating poles in synchronous converters, with special reference to interurban service where load-factor is very low. Additional data on the design and limiting factors in synchronous converter construction.

## D. SUB-STATIONS

## THE STORAGE-BATTERY IN SUB-STATIONS

W. E. Goldsborough and P. E. Fansler

Vol. xxii—1903, pp. 243-277

Description of Indiana Union Traction Company distribution system. Account and results of tests showing the efficiency of the various parts of the system, the performance and requirements of storage batteries in sub-stations. Graphic records of battery performance.

*Discussion*, incorporated with that of paper by Clarence Renshaw on "Some Notes on the Operation of Railway Motors in Service."

**THE COMPARATIVE BEHAVIOR OF FLOATING AND BOOSTER-CONTROLLED  
BATTERIES ON FLUCTUATING LOADS**

Lamar Lyndon

Vol. xxii—1903, pp. 705-731

Analysis of the performance of an electric railway plant with storage battery arranged in the following ways: Floating battery in station; floating battery on line; battery and booster on line; battery on the line and booster in the station. Numerical examples and comparison of the merits of different systems.

*Discussion*, pp. 732-734, by Messrs. J. R. Appleton, J. L. Woodbridge, W. E. Goldsborough, J. W. Lieb, Jr., W. W. Donaldson, A. S. Hubbard, F. L. Flanders, and H. Etheridge.

Lead batteries for high discharge rates. E.m.f. characteristic of Edison battery under rapid discharge.

**THE RELATION OF RAILWAY SUB-STATION DESIGN TO ITS OPERATION**

Sydney W. Ashe

Vol. xxiv—1905, pp. 1079-1096

Superficial discussion of certain factors which have a bearing on the choice and location of synchronous converter sub-station apparatus.

*Discussion*, incorporated with that of paper by C. W. Ricker on "Some Considerations Determining the Location of Electric Railway Sub-stations."

**SOME CONSIDERATIONS DETERMINING THE LOCATION OF  
ELECTRIC RAILWAY SUB-STATIONS**

C. W. Ricker

Vol. xxiv—1905, pp. 1097-1106

Calculation of the most economical number of sub-stations for a given set of conditions, the secondary copper being proportioned by Kelvin's law in one instance and by limiting drop in the other.

*Discussion* (including that of paper by Sydney W. Ashe on "The Relation of Railway Sub-station Design to Its Operation"), pp. 1107-1118, by Messrs. H. A. Lardner, W. I. Slichter, John B. Taylor, H. G. Stott, E. M. Hewlett, D. B. Rushmore, R. B. Owens, William McClellan, and C. P. Steinmetz.

Relative merits of different methods of starting synchronous converters. Effect of maximum allowable drop upon location of synchronous converter sub-station.

**THE DETERMINATION OF THE ECONOMIC LOCATION OF SUB-STATIONS  
IN ELECTRIC RAILWAYS**

Gerhard B. Werner

Vol. xxvii—1908, pp. 1201-1212

Development of a formula for determining the most economical number of sub-stations for a given single-phase railway system.

*Discussion*, pp. 1213-1214, by Messrs. C. J. Hopkins, Gerard B. Werner, and P. M. Lincoln.

## E. OPERATION

## AN ELECTRIC CAR LIGHTING SYSTEM

W. L. Bliss

Vol. xxi—1903, pp. 133-154

Description of an axle-driven car lighting system with generator and storage battery, the e. m. f. being controlled by special booster. Detailed explanation of the construction and mode of operation, so as to produce constant e. m. f. under usual conditions of railway service.

*Discussion*, incorporated with that of paper by George D. Shepardson on "Some of the Problems of Electric Train Lighting."

## AXLE-LIGHTING

Elmer A. Sperry

Vol. xxi—1903, pp. 155-162

Reference to some of the earliest electric car lighting installations. Criticisms of present methods and announcement of method employing an axle-driven constant-speed generator.

*Discussion*, incorporated with that of paper by George D. Shepardson on "Some of the Problems of Electric Train Lighting."

## AN AXLE-LIGHT SYSTEM OF TRAIN LIGHTING

Arthur J. Farnsworth

Vol. xxi—1903, pp. 163-172

Description of axle-driven car lighting system with generator e. m. f. kept constant by automatically varying resistance of field circuit. Battery voltage also compensated with variable resistance.

*Discussion*, incorporated with that of paper by George D. Shepardson on "Some of the Problems of Electric Train Lighting."

## SOME OF THE PROBLEMS OF ELECTRIC TRAIN LIGHTING

Geo. D. Shepardson

Vol. xxi—1903, pp. 173-178

Dates of some of the earliest applications of electricity to lighting of cars. Short outline of the requirements of train lighting and discussion of some of the difficulties encountered in each typical system.

*Discussion* (including that of paper by W. L. Bliss on "An Electric Car Lighting System," paper by Elmer A. Sperry on "Axle-Lighting," and paper by Arthur J. Farnsworth on "Axle-Light System of Train Lighting"), pp. 179-195 and 208-227, by C. F. Scott, Professor Carhart, Lamar Lyndon, W. L. Bliss, Max Von Recklinghausen, George W. Blodgett, C. W. Hogan, Charles B. Lockwood, J. R. Sloane, Elmer A. Sperry, James F. McElroy, Carl Hering, Charles J. Dudley, Ralph W. Pope, Hugh Lesley, C. W. Woodward, Charles Hewitt, W. C. L. Eglin, Charles J. Reed, Philip L. Spalding, John B. Klumpp, J. S. Peck, N. W. Storer, A. H. Masters, B. B. Abry, J. M. Campbell, P. M. Lincoln, A. H. Armstrong, C. P. Steinmetz, W. I. Slichter, and R. Neil Williams.

General remarks on train lighting. Relative merits of engine-driven and axle-driven units. Difficulties and limitations of different systems. Description of actual equipments. Description of Gould car lighting system. Cost of operating various lighting systems—oil, gas, and electric.

## A SYSTEM OF ELECTRIC LIGHTING FOR CARS

Jas. F. McElroy

Vol. xxi—1903, pp. 197-207

Description of the McElroy axle-driven train lighting system, the e. m. f. being kept constant by a variable resistance operated by a motor and controlled through a compound solenoid.

No discussion.

## ELECTRICAL FEATURES OF BLOCK SIGNALING

L. H. Thullen

Vol. xxiv—1905, pp. 577-589

Brief remarks on signal systems used on several electric railways. Effect of air-gap on impedance of inductive bonds carrying various amounts of direct current.

*Discussion*, p. 590, by Mr. H. G. Stott.

## TRACK-CIRCUIT SIGNALING ON ELECTRIFIED ROADS

L. Frederick Howard

Vol. xxvi—1907, pp. 1535-1550

Description of various types of single-rail and double-rail track-circuit signaling systems for direct-current and alternating-current roads, with circuit diagrams of systems used on some of the leading electric railways.

*Discussion*, pp. 1551-1553, by Messrs. Charles F. Scott, Henry G. Stott, Charles A. Perkins, and L. F. Howard.

## THE LOG OF THE NEW HAVEN ELECTRIFICATION

W. S. Murray

Vol. xxvii—1908, pp. 1613-1664

Detailed account of the troubles encountered in the first four months' operation of the electric zone of the New Haven road, covering power plant (three-phase turbo-generators load on one phase), distribution system and locomotives. Complete tabular and graphical logs of delays, repairs, locomotive performance, etc., supplemented by measures to overcome the various difficulties encountered.

*Discussion*, pp. 1665-1719, by Messrs. L. A. Ferguson, Calvert Townley, B. G. Lamme, L. B. Stillwell, E. B. Katte, H. P. Davis, Charles P. Steinmetz, Philip Torchio, Minor M. Davis, B. A. Behrend, H. F. Parshall, A. H. Armstrong, N. W. Storer, O. S. Lyford, Jr., W. N. Smith, Philip Dawson, Ivan Ofverholm, C. E. Eveleth, and W. S. Murray.

Additional information on the performance of the New Haven single-phase locomotives, the generators and the improved circuit breaking apparatus. Comparison of the New Haven single-phase locomotive and the New York Central direct-current locomotive. Operation experience with the single-phase line of the Erie Railroad. Overhead catenary construction of the London, Brighton and South Coast Railway.

## HEADLIGHT TESTS

C. Francis Harding and A. N. Topping

Vol. xxix—1910, pp. 1053-1081

Experimental investigation of locomotive headlights to ascertain the relative merits of ordinary oil and powerful electric headlights. Road tests on the operation of colored light signals and obstructions on the tracks. Laboratory tests of illumination characteristics; spectral intensities, and reflections from signal lamp roundels with different types of headlights. Tabulated and plotted data and characteristic curves of the performance of the different types of headlights.

*Discussion*, pp. 1082-1089, by Messrs. C. A. B. Halvorson, Jr., John B. Taylor, George H. Stickney, Harry Barker, C. P. Steinmetz, Charles F. Scott, George A. Hoadley, Harry P. Wood, J. C. Lincoln, and C. Francis Harding.

General discussion of high-power *vs.* low-power headlights, with some results of tests.

## F. INDUSTRIAL RAILWAYS AND TELPHERAGE

## TELPHERAGE

Chas. M. Clark

Vol. xix—1902, pp. 435-453

Brief outline of history of development of telferage. Description of present methods of construction and operation, profusely illustrated with line drawings and photographs of different types of machinery and methods of application.

*Discussion* (included with that of paper by George F. Sever on "Power Consumption of Elevators Operated by Alternating and Direct-Current Motors"), pp. 454-486, by Messrs. Charles P. Steinmetz, John D. Ihlder, A. V. Abbott, Philip Torchio, Ralph D. Mershon, George F. Sever, Arthur Williams, Edward P. Thompson, F. V. Henshaw, H. G. Stott, Douglass Burnett, F. H. Taylor, M. Wellman, Henry H. Humphrey, P. B. Woodworth, R. H. Pierce, James Lyman, David Lofts, J. W. Mabbs, A. D. Ayres, M. Hobart, A. H. Cutler, E. B. Clark, and L. A. Nichols.

Load characteristics and power requirements of elevator service. Alternating-current *vs.* direct-current motors for elevator service. Acceleration, speed and energy consumption in electric elevator service.

## STORAGE-BATTERY INDUSTRIAL LOCOMOTIVES

F. L. Sessions

Vol. xxii—1903, pp. 109-123

General discussion of storage-battery locomotives—their advantages; methods of operating the battery; calculation of battery rating for given service; motor control, etc. Tables for facilitating the calculation of storage-battery rating, with numerical example illustrating their use.

*Discussion*, pp. 124-131, by Messrs. Edgar H. Berry, F. L. Sessions, and Elmer A. Sperry.

General remarks on storage-battery performance in industrial locomotive service, and criticisms of author's tables.



G. CANAL BOAT HAULAGE

NOTES ON ELECTRIC HAULAGE OF CANAL BOATS

Lewis B. Stillwell and H. St. Clair Putnam

Vol. xxvii—1908, pp. 227-316

Description of tests made on the Lehigh Canal, to determine the power requirements, the speed and length of tow and the relative merits of mules, electric locomotives and electric tractors. A general discussion of canal-boat resistance comparing these tests with the results of those of other tests.

*Discussion*, pp. 317-320, by Messrs. Richard Lamb, Charles P. Steinmetz, and L. B. Stillwell.

## 18. LIGHT LIGHTING AND LAMPS

### A. LIGHT PRODUCTION AND MEASUREMENT

#### A NOTE ON AN ACETYLENE-IN-OXYGEN FLAME

Clayton H. Sharp

Vol. xix—1902, pp. 51-54

Description of an acetylene flame burner which might be used as a standard of intensity. Spectrophotometric curve of acetylene and other flames.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

#### THE PRESENT STATUS OF THE QUESTION OF A STANDARD OF LIGHT

Clayton H. Sharp

Vol. xix—1902, pp. 55-57

Brief reference to some of the shortcomings of the present standards of luminous intensity. Advantages of acetylene flame as standard.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

### PHOTOMETRY AND ILLUMINATION

Chas. F. Scott

Vol. xx—1902, pp. 55-57

#### AN INTEGRATING PHOTOMETER FOR GLOW LAMPS AND SOURCES OF LIGHT INTENSITY

Chas. P. Matthews

Vol. xx—1902, pp. 59-70

Theory, design, construction and operation of a special intensity photometer invented by the author for use in making photometric measurements of incandescent lamps and flames.

*Discussion*, incorporated with that of paper by Clayton H. Sharp on "The Commercial Accuracy of Photometrical Measurements."

#### SOME METHODS OF PHOTOMETRY AS APPLIED TO INCANDESCENT LAMPS

J. T. Marshall,

Vol. xx—1902, pp. 77-85

A description of method of calibrating and using sliding scale photometer for commercial testing and inspection of incandescent lamps.

*Discussion*, incorporated with that of paper by Clayton H. Sharp on "The Commercial Accuracy of Photometrical Measurements."

#### THE COMMERCIAL ACCURACY OF PHOTOMETRICAL MEASUREMENTS

Clayton H. Sharp

Vol. xx—1902, pp. 87-93

Experimental investigation of the limits of accuracy in different classes of photometrical measurements.

*Discussion* (including that of paper by Charles P. Matthews on "Integrating Photometer for Glow Lamps and Sources of Light Intensity;" paper by Douglass Burnett on "Distributed Lighting," and paper by J. T.

Marshall on "Some Methods of Photometry as Applied to Incandescent Lamps"), pp. 94-110, by Messrs. Douglass Burnett, Edward L. Nichols, Francis R. Upton, L. B. Marks, W. S. Howell, F. S. Smith, Edward B. Rosa, Calvin W. Rice, William J. Hammer, W. S. Stratton, Clayton H. Sharp, J. T. Marshall, Charles F. Scott, Charles P. Matthews, Edward P. Thompson, Alex J. Wurts, R. H. Henderson, Max Von Reckinghausen, P. M. Lincoln, N. W. Storer, and F. W. Jones.

Merits of mean spherical candle-power method of rating illuminants. Methods of measuring illumination. Description of Cooper-Hewitt mercury vapor lamp.

#### TRANSFORMATION OF ELECTRIC POWER INTO LIGHT

Charles P. Steinmetz

Vol. xxv—1906, pp. 789-813

Analytical discussion of the different methods of transforming electric energy into light, covering incandescent solids, selective radiation and luminescence of vapors and gases. Ideal efficiencies of the various methods and practical means of approaching them with the modern types of illuminants.

Equations for volt-ampere characteristics of various kinds of arcs. Theory of arc conduction and e. m. f. rectification.

*Discussion*, incorporated with paper by Clayton H. Sharp on "New Types of Incandescent Lamps."

#### PRIMARY STANDARD OF LIGHT

Charles P. Steinmetz

Vol. xxvii—1908, pp. 1319-1324

Criticism of primary standard based on energy of radiation, recommending standard composed of three component colors of definite wave lengths.

*Discussion*, pp. 1325-1339, by Messrs. A. E. Kennelly, Edwin P. Hyde, W. S. Franklin, Carl Hering, Clayton H. Sharp, C. A. Perkins, John B. Taylor, E. B. Rosa, H. S. Carhart, and Charles P. Steinmetz.

General remarks on Steinmetz' proposed standard. Motion carried to refer question of establishing standard to the Bureau of Standards.

### B. LIGHTING

#### METHODS OF ILLUMINATION

Louis Bell

Vol. xix—1902, pp. 5-27

A discussion on the physiological and practical side of illumination. Outline of the qualities that should be possessed by illuminants for practical illumination. Discussion of the present status of light standards and the art of photometric measurements. Requirements of street lighting and general indoor lighting, with characteristics and relative merits of various illuminants.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

## STREET ILLUMINATION AND UNITS OF LIGHT

W. D'A Ryan

Vol. xix—1902, pp. 29-41

Photometric study of arc lamps for street lighting, showing the effects of variation, wandering and flicker of the arc on the distribution of the light, and of candle-power and spacing on the energy consumption for a given illumination. Tests on open and enclosed direct-current and alternating-current arc lamps.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

## SOME COMMON DIFFICULTIES IN EXTERIOR ILLUMINATION

S. Everett Doane

Vol. xix—1902, pp. 43-46

Consideration of the actual value of illumination to observer, showing effect of candle-power and spacing of lamps thereon. Advantages of incandescent lamps for street lighting.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

## DISTRIBUTED LIGHTING

Douglass Burnett

Vol. xx—1902, pp. 71-76

General discussion of indirect lighting, pointing out the effects of reflection and diffusion on illumination. Suggested method of measuring illumination directly. Bibliography.

*Discussion*, incorporated with that of paper by Clayton H. Sharp on "The Commercial Accuracy of Photometrical Measurements."

## RAILWAY TRAIN LIGHTING

Chas. F. Scott

Vol. xxi—1903, pp. 129-131

## AN ELECTRIC CAR LIGHTING SYSTEM.

W. L. Bliss

Vol. xxi—1903, pp. 133-154

Description of an axle-driven car lighting system with generator and storage battery, the e. m. f. being controlled by special booster. Detailed explanation of the construction and mode of operation, so as to produce constant e. m. f. under usual conditions of railway service.

*Discussion*, incorporated with that of paper by George D. Shepardson on "Some of the Problems of Electric Train Lighting."

## AXLE-LIGHTING

Elmer A. Sperry

Vol. xxi—1903, pp. 155-162

Reference to some of the earliest electric car lighting installations. Criticisms of present methods and announcement of method employing an axle-driven constant-speed generator.

*Discussion*, incorporated with that of paper by George D. Shepardson on "Some of the Problems of Electric Train Lighting."

## AN AXLE-LIGHT SYSTEM OF TRAIN-LIGHTING

Arthur J. Farnsworth

Vol. xxi—1903, pp. 163-172

Description of axle-driven car lighting system with generator e. m. f. kept constant by automatically varying resistance of field circuit. Battery voltage also compensated with variable resistance.

*Discussion*, incorporated with that of paper by George D. Shepardson on "Some of the Problems of Electrain Train Lighting."

## SOME OF THE PROBLEMS OF ELECTRIC TRAIN LIGHTING

Geo. D. Shepardson

Vol. xxi—1903, pp. 173-178

Dates of some of the earliest applications of electricity to lighting of cars. Short outline of the requirements of train lighting and discussion of some of the difficulties encountered in each typical system.

*Discussion* (including that of paper by W. L. Bliss on "An Electric Car Lighting System," paper by Elmer A. Sperry on "Axle-Lighting," and paper by Arthur J. Farnsworth on "Axle-Light System of Train Lighting"), pp. 179-195 and 208-227, by C. F. Scott, Professor Carhart, Lamar Lyndon, W. L. Bliss, Max Von Recklinghausen, George W. Blodgett, C. W. Hogan, Lockwood, J. R. Sloane, Elmer A. Sperry, James F. McElroy, Carl Hering, Charles B. Dudley, Ralph W. Pope, Hugh Lesley, C. W. Woodward, Charles Hewitt, W. C. L. Eglin, Charles J. Reed, Philip L. Spalding, John B. Klumpp, J. S. Peck, N. W. Storer, A. H. Masters, B. B. Abry, J. M. Campbell, P. M. Lincoln, A. H. Armstrong, C. P. Steinmetz, W. I. Slichter, and R. Neil Williams.

General remarks on train lighting. Relative merits of engine driven and axle-driven units. Difficulties and limitations of different systems. Description of actual equipments. Description of Gould car lighting system. Cost of operating various lighting systems—oil, gas, and electric.

## A SYSTEM OF ELECTRIC LIGHTING FOR CARS

Jas. F. McElroy

Vol. xxi—1903, pp. 197-207

Description of the McElroy axle-driven train lighting system, the e. m. f. being kept constant by a variable resistance operated by a motor and controlled through a compound solenoid.

No discussion.

## NOTES ON THE LIGHTING OF CHURCHES

Edwin R. Weeks

Vol. xxv—1906, pp. 643-648

General remarks on church lighting with outlet plan, and excerpts from the specifications for the Westminster Church in Kansas City.

No discussion.

## ILLUMINATION FOR INDUSTRIAL PLANTS

G. H. Stickney

Vol. xxix—1910, pp. 139-146

General discussion of lighting of manufacturing processes, with due regard to workmen, character of the building and processes of manufac-

ture, supplemented with a short characterization of the different types of lamps with reference to their industrial uses.

*Discussion*, incorporated with that of Mr. Walter B. Nye's paper on "The Requirements for an Induction Motor From the User's Point of View."

#### HEADLIGHT TESTS

C. Francis Harding and A. N. Topping

Vol. xxix—1910, pp. 1053-1081

Experimental investigation of locomotive headlights to ascertain the relative merits of ordinary oil and powerful electric headlights. Road tests on the operation of colored light signals and obstructions on the tracks. Laboratory tests of illumination characteristics, spectral intensities, and reflections from signal lamp roundels with different types of headlights. Tabulated and plotted data and characteristic curves of the performance of different types of headlights.

*Discussion*, pp. 1082-1089, by Messrs. C. A. B. Halvorson, Jr., John B. Taylor, George H. Stickney, Harry Barker, C. P. Steinmetz, Charles F. Scott, George A. Hoadley, Harry P. Wood, J. C. Lincoln, and C. Francis Harding.

General discussion of high power *vs.* low power headlights, with some results of tests.

#### C. LAMPS

##### DEVELOPMENT OF THE NERNST LAMP IN AMERICA

Alexander Jay Wurtz

Vol. xviii—1901, pp. 545-570

Account of the experimental investigation involved in commercial development of the Nernst lamp by the Westinghouse Company, covering the construction and the performance characteristics of the component parts under various conditions; also a description of the construction, performance and maintenance of the complete lamp in its commercial form.

*Discussion*, pp. 571-587, by Messrs. George W. Blodgett, A. J. Wurts, Carl Hering, J. W. Howell, Charles P. Steinmetz, W. J. Hammer, Oberlin Smith, L. B. Stillwell, P. K. Stern, Harry Alexander, and A. J. Rowland.

General discussion of the characteristics of the Nernst lamp and its probable features.

##### AN IMPROVED APPARATUS FOR ARC-LIGHT PHOTOMETRY

Charles P. Matthews

Vol. xviii—1901, pp. 677-689

Development of theory and description of construction and operation of Matthews indicating photometer for arc lamps.

*Discussion*, pp. 690-697, by Messrs. Charles P. Steinmetz, Clayton H. Sharp, Charles P. Matthews, C. J. Spencer, George T. Hanchett, F. S. Woodward, and A. E. Kennelly.

General remarks on operation and construction of the photometer.

## THE INCANDESCENT LAMP OF TO-DAY

Jno. W. Howell

Vol. xix—1902, pp. 47-49

Brief statement of the most prominent characteristics of carbon filament lamps.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

## ELECTRIC GAS LAMPS AND GAS ELECTRICAL RESISTANCE PHENOMENA

Peter Cooper Hewitt

Vol. xix—1902, pp. 59-65

Brief account of some of the difficulties encountered in developing the mercury vapor arc lamp. Choice of dimensions of gas column, overcoming the initial negative resistance, etc.

*Discussion*, incorporated with that of paper by William J. Hammer on "Edison's Tungstate of Calcium Lamp—The Nernst Lamp—Radium, Polonium and Actium."

## EDISON'S TUNGSTATE OF CALCIUM LAMP—THE NERNST LAMP—RADIUM, POLONIUM AND ACTINIUM

William J. Hammer

Vol. xix—1902, pp. 67-75

Demonstration of Edison X-Ray lamp and the Nernst lamp. Superficial review of the properties of radium. Appendix contains notes by Professor Curie on the properties of radium.

*Discussion* (including that of paper by Louis Bell on "Methods of Illumination;" paper by W. D'A. Ryan on "Street Illumination and Units of Light;" paper by S. Everett Doane on "Some Common Faults in Exterior Illumination;" paper by John W. Howell on "The Incandescent Lamp of To-day;" paper by Clayton H. Sharp on "A Note on an Acetylene-in-Oxygen Flame;" paper by Clayton H. Sharp on "The Present Status of the Question of a Standard of Light;" and paper by Peter Cooper Hewitt on "Electric Gas Lamps and Gas Electrical Resistance Phenomena"), pp. 76-92, by Messrs. C. P. Steinmetz, J. W. Lieb, Jr., A. E. Wolff, A. E. Kennelly, Louis Bell, C. A. Doremus, S. E. Doane, George T. Hanchett, W. D'A. Ryan, John W. Howell, W. J. Hammer, T. J. Johnston, Van Rensselaer Lansingh, T. B. Woodworth, Morgan Brooks, and W. B. Hale.

General discussion of light production and illumination—incandescence, selective radiation, electro-luminescence, indirect lighting. Present status of primary standards. Sources of error with flame standards.

## THE MERCURY VAPOR LAMP

Vol. xxii—1903, pp. 71-85

General discussion of the early development of the mercury vapor lamp, followed by a description of the mode of operation of the mercury vapor lamp and the converter. Uses to which this apparatus may be put.

*Discussion*, pp. 85-90, by Messrs. Percy H. Thomas, C. O. Mailloux.

Properties and performance characteristics of mercury vapor apparatus.

COMMENTS ON REMARKS MADE BY COL. R. E. B. CROMPTON BEFORE THE  
INTERNATIONAL ELECTRICAL CONGRESS AT ST. LOUIS

John W. Howell

Vol. xxiv—1905, pp. 453-462

Experimental investigation of the quality of English makes of 220-volt carbon filament lamps, comparing them with American lamps as judged by specific consumption, uniformity and accuracy of rating and life.

*Discussion*, p. 463, by Messrs. J. W. Lieb, Jr., Charles P. Steinmetz, and J. W. Howell.

A NEW CARBON FILAMENT

John W. Howell

Vol. xxiv—1905—pp. 839-847

Brief description of process of graphitizing filaments, together with results of tests showing effect of firing temperature on resistance.

*Discussion*, pp. 848-849, by Messrs. H. N. Potter, and John W. Howell.

NOTES ON THE POWER-FACTOR OF THE ALTERNATING-CURRENT ARC

George D. Shepardson

Vol. xxiv—1905, pp. 881-887

Brief account of tests on enclosed and open carbon arcs, showing the effect of e. m. f. wave form upon power-factor. Oscillographs.

No discussion.

SOME FUNDAMENTAL CHARACTERISTICS OF MERCURY VAPOR APPARATUS

Percy H. Thomas

Vol. xxv—1906, pp. 601-626

Electrical characteristics of mercury arc lamps and converters, with theoretical explanation of mode of operation and description of ways in which the various mercury vapor apparatus are used.

*Discussion*, pp. 627-633, by Messrs. C. P. Steinmetz, S. S. Wheeler, H. C. Wirt, and P. H. Thomas.

Explanation of performance of mercury arc on same basis as the ordinary arc, with equation of e. m. f. consumed. Principles of conservation of energy used to explain operation of mercury vapor apparatus as opposed to negative electrode resistance idea.

NEW TYPES OF INCANDESCENT LAMPS

Clayton H. Sharp

Vol. xxv—1906, pp. 815-847

Brief description of various foreign processes of manufacturing tungsten filaments, together with physical and electrical characteristics of tungsten, tantalum and osmium filaments. Light distribution, specific consumption, life, flicker frequency and other properties of metallic filament and graphitized filament lamps from tests, much test data given in the form of curves and tables.

*Discussion* (included with paper by Charles P. Steinmetz on "Transformation of Electric Power into Light"), pp. 849-864, by Messrs. Herschel C. Parker, John W. Howell, Percy H. Thomas, Walter G.



Clark, C. W. Hogan, Charles P. Steinmetz, William J. Hammer, and W. S. Franklin.

General remarks on practical methods of producing light with modern illuminants. Ideal efficiencies. Theory of light emission by gas and vapor molecules, also theoretical discussion of selective radiation and selective excitation of a light giving substance.

#### LIGHT FROM GASEOUS CONDUCTORS WITHIN GLASS TUBES—THE MOORE LIGHT

D. McFarlan Moore

Vol. xxvi—1907, pp. 605-641

Description of the construction and mode of operation of the Moore tube lamp, together with illumination tests, performance characteristics, life, specific energy consumption, etc., also comparative tests with other illuminants.

*Discussion*, pp. 642-664, by Messrs. Gano Dunn, C. P. Steinmetz, Percy H. Thomas, Clayton H. Sharp, John W. Howell, Leon Gaster, D. McFarlan Moore, and R. A. Fessenden.

Criticism of methods of illumination measurements and comparative efficiency figures given in the paper. Additional data and tests on the performance of the Moore tube installed in the Engineering Societies' Building.

#### ELECTRICITY IN MINES

George R. Wood

Vol. xxvii—1908, pp. 1571-1581

Brief outline of the ordinary methods of mining coal in Pennsylvania, with description of some of the typical machinery and coal mining electric plants.

*Discussion*, pp. 1582-1583, by Messrs. F. L. Sessions, W. A. Thomas, and H. W. Fisher.

Saving accomplished by use of low-pressure turbines in coal mines.

#### METAL FILAMENT LAMPS

John W. Howell,

Vol. xxix—1910, pp. 927-938

Brief description of the physical, electrical and thermal properties, operative characteristics and testing of metallic filament lamps.

*Discussion*, pp. 939-960, by Messrs. Clayton H. Sharp, John B. Taylor, Farley Osgood, William L. Nodell, John W. Howell, G. S. Merrill, M. D. Copper, and H. D. Blake.

Remarks on cyclic and initial overshooting, life and rating; also brief account and results of exhaustive experimental investigation of the performance of tungsten lamps.

#### DUCTILE TUNGSTEN

W. D. Coolidge

Vol. xxix—1910, pp. 961-965

Brief outline of difficulties encountered in the working of tungsten for filaments, together with some of the properties of drawn tungsten filaments.

No discussion.

## TUNGSTEN LAMPS

G. S. Merrill

Vol. xxix—1910, pp. 1709-1729

Description of the general method of manufacturing and of the performance characteristics of the tungsten lamps. Explanation of the heat efficiency of this type of lamp.

No discussion.

## 19. ELECTRICITY IN THE ARMY AND NAVY

### CIVILIAN CO-OPERATION IN THE DEVELOPMENT OF ELECTRICAL DEFENSES FOR MILITARY PURPOSES

Caryl D. Haskins

Vol. xix—1902, pp. 559-562

Brief mention of some of the uses of electricity in the army, indicating the field in which the civilian engineer could be of most service in case of an emergency.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defense."

### ELECTRICITY IN ITS APPLICATION TO SUBMARINE MINES

Capt. John Stephen Sewell

Vol. xix—1902, pp. 563-568

General discussion of the requirements of electrically operated mines, bringing out the difficulties encountered in the design of such systems.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

### WIRELESS TELEGRAPHY IN THE UNITED STATES NAVY

Lieut. A. M. Beecher

Vol. xix—1902, pp. 569-578

Description of the general principles of wireless telegraph systems and account of what has actually been done in the navy.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

### ELECTRICITY IN THE NAVY

Lieut. Harry George

Vol. xix—1902, pp. 579-628

General description of the applications of electricity on board war ships, with brief outline of the specifications for the generating, wiring and apparatus plant—construction, properties and acceptance tests, as well as the power requirements and mode of operation of various special apparatus such as ammunition hoists, turrets, signal lights and telegraphs, etc.

*Discussion*, included with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

### THE REASONS FOR THE CHANGE OF THE NAVY STANDARD VOLTAGE FROM 80 TO 125

Lieut. W. V. N. Powelson

Vol. xix—1902, pp. 643-664

History of voltages used in the navy. Table showing relative costs and weights of wiring materials for operation at 80 volts and at 125 volts.

Detailed discussion of the reasons for adopting 125 volts as the navy standard.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

**ELECTRICITY IN PROMINENT SEA COAST DEFENCES**

Major Geo. W. Goethals

Vol. xix—1902, pp. 665-683

Description of the general character and arrangement of sea coast forts, giving the requirements and characteristics of the electric service, also the considerations which enter into the drawing up of specifications for the electric equipment of such plants.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

**SUB-MARINE CABLE TESTING IN THE SIGNAL CORPS U. S. ARMY**

Vol. xix—1902, pp. 685-695

General description of the electrical and mechanical specifications for Signal Corps cable and the tests which it must undergo. Change of insulation resistance with temperature treated in detail, and a chart given for reducing resistances to standard temperatures.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

**ELECTRICITY IN THE NAVY**

Walter M. McFarland

Vol. xix—1902, pp. 697-705

Brief general review of the uses of electricity in the navy. Criticism of the low temperature limit required by navy specifications. Advantages of alternating current for use on board ship and in navy yards.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

**ELECTRICITY IN THE SIGNAL CORPS**

Lieut. Col. Samuel Reber

Vol. xix—1902, pp. 707-724

Scope of the duties of the Army Signal Corps. Telegraph and telephone construction in the field and in fortresses. Detailed description of signal apparatus used in the army.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

**EMERGENCY ENGINEERING FOR HARBOR DEFENCE**

Louis Bell

Vol. xix—1902, pp. 725-733

Account of experiences of the Volunteer Electrical Corps formed at Boston during the Spanish War for the construction of mining defences.

*Discussion* (including that of paper by Carl B. Haskins on "Civilian Coöperation in the Development of Electrical Defences for Military Purposes," by Captain John Stephen Sewell on "Electricity in Its Application to Submarine Mines," paper by Lieutenant A. M. Beecher on "Wireless Telegraphy in the U. S. Navy," paper by Lieutenant Harry George on "Electricity in the Navy," paper by Captain Edgar Russel on "Military Cable System of the Philippines," paper by Lieutenant W. V. N. Powelson on "The Reasons for the Change of the Navy Standard

Voltage from 80 to 125," by Major George W. Goethals on "Electricity in Prominent Sea Coast Defences;" paper by Townsend Wolcott on "Submarine Cable Testing in the Signal Corps,—U. S. Army;" paper by Walter M. McFarland on "Electricity in the Navy," and by Lieutenant Colonel Samuel Reber on "Electricity in the Signal Corps"), pp. 734-742, by Messrs. Samuel Reber, Harry George, Eugene Griffin, A. V. Abbott, A. M. Beecher, A. W. Greely, Calvin W. Rice, and George T. Hanchett.

Defence of the navy specifications. General discussion of wireless telegraphy.

## 20. MISCELLANEOUS APPLICATIONS OF ELECTRICITY

### A. ELECTROCHEMISTRY AND METALLURGY

#### THE ELECTROCHEMICAL INDUSTRIES

Samuel Sheldon

Vol. xix—1902, pp. 281-294

Brief description of various commercial electro-chemical processes—electro-deposition of metals; production of organic and inorganic substances; process involving the use of electric furnaces. Also brief description of electrolytic condensers, rectifiers and interrupters.

*Discussion*, incorporated with that of paper by W. R. Whitney on "Colloids."

#### THE ELECTRIC FURNACE IN INDUSTRIAL CHEMISTRY

Chas. B. Jacobs

Vol. xix—1902, pp. 295-307

Description of several important processes carried on with electric furnaces, and discussion of the characteristics and properties of carbides and silicides.

*Discussion*, incorporated with that of paper by W. R. Whitney on "Colloids."

#### ELECTROLYTIC CONDUCTION WITHOUT ELECTRODES

Carl Hering

Vol. xix—1902, pp. 309-315

Theoretical discussion of possible methods of producing and measuring electric current in a purely liquid conductor.

*Discussion*, incorporated with that of paper by W. R. Whitney on "Colloids."

#### LOW GRADE ORES

N. S. Keith

Vol. xix—1902, pp. 333-341

Description of a process and plant for recovering copper from ores of an old mine near New York City.

*Discussion*, incorporated with that of paper by W. R. Whitney on "Colloids."

#### ON THE MODIFICATIONS IN HERING'S LAWS OF FURNACE ELECTRODES INTRODUCED BY INCLUDING VARIATIONS IN ELECTRIC AND THERMAL RESISTIVITY

A. E. Kennelly

Vol. xxix—1910, pp. 465-481

Theoretical and mathematical investigation of the losses in furnace electrodes, taking into account variations in the physical constants with temperature. The treatment includes full development of formulas and illustrates their application by numerical examples.

*Discussion*, pp. 482-484, by Messrs. Carl Hering, and L. B. Stillwell.  
General remarks on laws for the proportioning of electrodes.

## THE PROPORTIONING OF ELECTRODES FOR FURNACES

Carl Hering

Vol. xxix—1910, pp. 485-534

Analytical and experimental investigation of furnace electrode losses under furnace conditions with electrodes of various materials, developing simple laws for proportioning electrodes to operate with minimum loss. The tests, among other properties, give the electric resistivity and the thermal conductivity of graphite, iron and copper over wide ranges of temperature.

*Discussion*, pp. 535-545, by Messrs. A. E. Kennelly, and E. F. Northrup.

Thermal conductivities and temperature coefficients of electrode materials. Development of other formulas for proportioning electrodes.

## B. MINING

## ELECTRICITY IN MOUNTAIN MINES

Frank W. Brady

Vol. xviii—1901, pp. 191-201

Difficulties encountered in mountain transportation of machinery. Description of typical cases of mountain transportation: burro, aerial, wire rope and wagon road.

*Discussion*, pp. 202-206, by Messrs. N. S. Keith, C. O. Mailloux, Ralph W. Pope, and Carl Hering.

## THE ELECTRICAL EQUIPMENT OF A GOLD DREDGE

Ralph L. Montagu

Vol. xxii—1903, pp. 507-518

Description of gold dredge and the power requirements of the various machines used in its operation. Directions and diagrams for wiring a typical dredge.

No discussion.

SOME NOTES ON CERTAIN UNDERGROUND HOISTING PROBLEMS  
ON THE WITWATERSRAND

A. W. K. Pierce

Vol. xxii—1903, pp. 553-559

General discussion of the advantages of electric motive power for mine hoists. The nature of the load requirements, choice of the acceleration curve and method of control.

No discussion.

## ELECTRIC MINE HOISTS

D. B. Rushmore and K. A. Pauly

Vol. xxix—1910, pp. 249-290

General discussion of the advantages of electric mine hoisting, with typical hoist load diagrams for different types of hoists, followed by brief description and analysis of the performance of four typical electrical hoisting systems. Estimated cost and energy consumption.

*Discussion*, incorporated with that of Mr. Wilfred Sykes' paper on "Large Electric Hoisting Plants."

## LARGE ELECTRICAL HOISTING PLANTS

Wilfred Sykes

Vol. xxix—1910, pp. 291-322

Analytical and graphical methods of calculating the load diagrams of various types of hoists, followed by a description of the Ilgner, the converter, and the booster balancing systems, together with instructions for pre-determining their performance curves under given conditions. Economy of electric hoisting.

*Discussion*, including that of paper by Messrs. D. B. Rushmore and K. A. Pauly on "Electric Mine Hoists," pp. 323-325, by Mr. Edward J. Cheney.

Formulas for the calculation of motor horse-power and motor rating for hoisting service.

## TESTS OF AN ILGNER ELECTRIC HOIST

R. R. Seeber,

Vol. xxix—1910, pp. 327-337

Brief description of electric hoisting plant of Winona Copper Company, with an account of tests and results. Comparison of actual coal-to-rock ratios for electric and steam hoists and observed performance curves of the Ilgner system.

No discussion.

## C. STEEL MILLS

## CHARACTERISTICS OF MOTORS FOR LARGE SHEARS

Brent Wiley

Vol. xxvii—1908, pp. 321-334

Discussion of the characteristics of different types of direct-current and alternating-current motors for driving large bloom shears, with actual load curves and full data of the machines tested.

No discussion.

## THE INDUSTRIAL APPLICATION OF THE ELECTRIC MOTOR AS ILLUSTRATED IN THE GARY PLANT OF THE INDIANA STEEL COMPANY

B. R. Shover

Vol. xxviii—1909, pp. 101-146

Description of electrical equipment of the Gary plant, with data on motor sizes and power required to operate steel-making machinery.

*Discussion*, pp. 147-161, by Messrs. B. A. Behrend, Gano Dunn, William T. Dean, Brent Wiley, Robert Hull, David B. Rushmore, Louis A. Ferguson, and B. R. Shover.

Additional data on and description of steel-making machinery. Design and operative features of large gas engines for parallel working.

## FUNCTION OF FLY-WHEELS IN CONNECTION WITH ELECTRICALLY OPERATED ROLLING MILLS

H. C. Specht

Vol. xxviii—1909, pp. 869-878

Theoretical analysis of the performance of induction motor rolling mill drive with varying amounts of fly-wheel effect. Numerical exam-



ples chosen to indicate the most economical combination for driving a given plate and rail mill.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

#### ROLLING MILL MOTORS

E. W. Yearsley

Vol. xxviii—1909, pp. 879-880

General requirements of rolling mill motor equipment.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

#### ELECTRIC DRIVEN ROLLING MILLS

E. Friedlander

Vol. xxviii—1909, pp. 881-887

General discussion of the advantages of electric drive in rolling mills.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

#### POWER REQUIREMENTS FOR ROLLING HIGH CARBON STEEL OF SMALL SECTION

Brent Wiley

Vol. xxviii—1909, pp. 889-895

Description of tests made on a merchant mill, giving tabulated data and recording wattmeter charts. All-day record of rolling mill, giving output, operating time, lost time, energy consumption, friction load, etc.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

#### ELECTRIC CONTROL FOR ROLLING MILL MOTORS

C. F. Henderson

Vol. xxviii—1909, pp. 897-912

Brief outline of essential requirements of controllers for motors operating ore handling machinery and rolling mills, with description of contactor type controller and various applications of automatic controllers in and about a steel mill.

*Discussion*, incorporated with that of Mr. R. Tschentscher's paper on "Electric Power Problems in Steel Plants."

#### ELECTRIC POWER PROBLEMS IN STEEL PLANTS

R. Tschentscher

Vol. xxviii—1909, pp. 921-930

Classification of steel mills and brief general discussion of power requirements of each type, together with analytical discussion of the economic value of low-pressure steam turbines in utilizing waste heat and of over-excited synchronous converters in improving power-factor, the latter being developed with special reference to application in the South Chicago plant of the Illinois Steel Company.

*Discussion*, pp. 931-946, by Messrs. David B. Rushmore, Brent Wiley,

K. A. Pauly, M. O. Delplain, S. Lankton Clark, H. C. Specht, Charles F. Scott, John C. Reed, H. E. White, A. M. Dudley, H. K. English, Arthur C. Eastwood, and Arthur Simon.

General discussion of design, control and operation of induction motor drive for rolling mills. Calculation of fly-wheel capacity. Detailed description of control system used on Hulett ore unloader.

#### INTERACTION OF FLY-WHEELS AND MOTORS WHEN DRIVING ROLL TRAINS BY INDUCTION MOTORS

F. G. Gasche

Vol. xxix—1910, pp. 1385-1402

General discussion of the application of fly-wheels to roll mill drive, followed by mathematical analysis of the forces acting in an induction motor fly-wheel set when coupled to a roll train, with a full mathematical development of the equations.

*Discussion*, pp. 1403-1414, by Messrs. C. P. Steinmetz, C. F. Scott, Gano Dunn, Selby Haar, W. W. Crawford, and F. G. Gasche.

Short-cut methods of calculating the performance of fly-wheel induction motor drive for roll trains.

### D. HEATING

#### NOTES ON THE ELECTRIC HEATING PLANT OF THE BILTMORE ESTATE

Chas. E. Waddell

Vol. xxvii—1908, pp. 651-666

Actual performance of large electric heating system for laundry, comparing this service with that of fuel-generated steam system, with respect to first cost of operation and convenience.

*Discussion*, pp. 667-668, by Messrs. Percy H. Thomas, Elmer A. Sperry, Charles E. Waddell, and John H. Finney.

Details of the electric steam generator and results of tests showing the fuel equivalent for one kilowatt hour.

#### ELECTRIC HEATING

W. S. Hadaway, Jr.

Vol. xxvii—1908, pp. 1585-1598

General discussion of the relative merits of electric energy and other forms of energy for operating a heat distribution system. Suggested plan for heating service in which electricity and steam are both used, one for general low-temperature heating and the other for high-temperature and localized heating.

*Discussion*, pp. 1599-1612, by Messrs. Charles E. Waddell, W. N. Ryerson, W. S. Andrews, H. P. Ball, Max Lowenthal, Charles P. Steinmetz, Townsend Wolcott, and W. S. Hadaway, Jr.

Storage of heat energy to improve load factor. Experience with electric heating of large buildings. Data on heating element design. Discussion of thermodynamic heating process.

## E. MISCELLANEOUS

## THE OPERATION OF MACHINE SHOPS BY INDIVIDUAL ELECTRIC MOTORS

R. T. E. Lozier

Vol. xx—1902, pp. 115-126

Load factor in machine shop practice and its effect on economy of various methods of supplying motive power. Review of electrical methods of speed control, going over respective limitations. Advantages of individual motor drive in high efficiency shop operation.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous Current Motors for Machine Tools."

## THE STORAGE BATTERY AS A FACTOR IN SPEED CONTROL

H. P. Coho

Vol. xx—1902, pp. 135-138

Brief description of electric drive for Hoe printing press, using storage battery for multi-voltage.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous-Current Motors for Machine Tools."

## ELECTRICALLY OPERATED COAL HOIST HAVING VARIABLE SPEED CONTROL

P. H. Keilholtz

Vol. xx—1902, pp. 139-142

Brief discussion of electric coal hoist equipped with Ward-Leonard system of speed control. Tests of power required, speed-time curves and other operative data.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous-Current Motors for Machine Tools."

## A SERIES-PARALLEL SYSTEM OF SPEED CONTROL

Geo. W. Fowler

Vol. xx—1902, pp. 143-153

Description of controller and its mode of operation as applied to double commutator motor driving webb press.

*Discussion*, incorporated with that of paper by F. O. Blackwell on "Continuous-Current Motors for Machine Tools."

## CONTINUOUS CURRENT MOTORS FOR MACHINE TOOLS

F. O. Blackwell

Vol. xx—1902, pp. 159-165

Power characteristics and requirements of various classes of machine tools. Brief mention of the different methods of speed control of electric motors and the advantages and limitations of each.

*Discussion* (including that of paper by R. T. E. Lozier on "The Operation of Machine Shops by Individual Electric Motors;" paper by N. W. Storer on "Three-Wire System for Variable Speed Motor Work;" paper by H. B. Coho on "The Storage Battery as a Factor in Speed Control;" paper by P. O. Keilholtz on "Electrically Operated Coal Hoist Having Variable Speed Control;" paper by George W. Fowler on "A Series-Parallel System of Speed Control;" and paper by H. Ward Leonard on "Multiple Unit, Voltage Speed Control for Trunk Line Service"), pp.

166-195, by Messrs. Gano S. Dunn, Charles F. Scott, H. E. Heath, S. T. Dodd, Arthur Williams, Philip Lange, Charles Day, R. T. E. Lozier, N. W. Storer, H. Ward Leonard, Herbert Dowe, H. B. Coho, George A. Damon, R. W. Stovel, George B. Dusingberre, W. A. Dick, P. M. Lincoln, — Campbell, Charles G. Winslow, E. M. Tingley, — Stevenson, — Barr, R. H. Pierce, Peter Junkersfeld, O. E. Osthoff, D. C. Jackson, B. J. Arnold, G. B. Foster, Ernest Gonzenbach, V. R. Lansingh, Harry H. Cutler, F. J. Pearson, and H. R. King.

Relative merits of various methods of speed control of direct-current motors. Conditions which determine the choice between individual and group drive. Effects of motor drive and suitable speed control on shop efficiency. Advantages and disadvantages of the Ward-Leonard system of locomotive driven from single-phase circuits.

#### METHODS OF SPEED CONTROL

Wm. Cooper

Vol. xx—1902, pp. 197-213

Outline of the general power requirements of the different classes of machine tools. Description of method of choosing proper size of motor for given service and speed range from a speed-horse-power diagram for combining multiple voltage and field regulation; numerical examples. Set of general rules for determining motor size.

No discussion.

#### POWER CONSUMPTION OF ELEVATORS OPERATED BY ALTERNATING AND DIRECT-CURRENT MOTORS

Geo. F. Sever

Vol. xix—1902, pp. 429-434

Records of tests on the comparative performances of direct-current and alternating-current motors in elevator service.

*Discussion*, incorporated with that of paper by Charles M. Clark on "Telpherage."

#### ELECTRIC MOTORS FOR CENTRIFUGAL PUMPS AND FANS

August J. Bowie, Jr.

Vol. xxii—1903, pp. 649-655

Power requirements and characteristics of centrifugal pumps under various conditions of operation.

*Discussion*, pp. 656, by Messrs. H. G. Stott, and F. O. Blackwell.

#### THE REQUIREMENTS FOR AN INDUCTION MOTOR FROM THE USER'S POINT OF VIEW

Walter B. Nye

Vol. xxix—1910, pp. 147-149

Brief mention of some of the conditions which must be met in the design of coils, bearings, shafts, pulleys and controllers so as to improve continuity of service and facilitate repairs.

*Discussion*, including that of paper by Mr. Dugald C. Jackson on "The Applicability of Electrical Power to Industrial Establishments;"

Mr. Charles T. Main's paper on "Central Stations *Versus* Isolated Plants for Textile Mills;" Mr. R. S. Hale's paper on "The Supply of Electrical Power for Industrial Establishments from Central Stations," and Mr. G. H. Stickney's paper on "Illumination for Industrial Plants"—pp. 150-182, by Messrs. J. C. Parker, Charles B. Burleigh, Norman T. Wilcox, H. B. Emerson, N. W. Dalton, H. W. Peck, R. D. DeWolf, Albert L. Pearson, H. D. James, C. A. Graves, J. H. Gardiner, and H. D. Jackson.

General discussion of the relative advantages and disadvantages of central station and private plant energy supply, together with figures and experience from actual practice. Brief description of decentralized system of electrical energy production in which moderate size non-condensing turbo-electric stations supply both electricity and steam to consumers, the stations being inter-connected both by the electric and the steam distribution systems.

#### ELECTRIC POWER IN THE CONSTRUCTION OF THE LOS ANGELES AQUEDUCT

E. F. Scattergood

Vol. xxix—1910, pp. 361-373

Description of the power plant and electrical equipment for the construction of a very long (240 miles) aqueduct, including power plant; transmission line and description of generating machinery; power shovels, dredges and locomotives. Costs of power plant and equipment.

No discussion.

#### ELECTRIC DRIVE IN TEXTILE MILLS

Alber Milnow

Vol. xxix—1910, pp. 385-422

Analytical discussion of electric drive of textile mills with energy purchased from water-power companies, comparing electric with steam operation as to first cost, cost of operation, and effect on production. The study includes a series of 50 recording tachometer records, showing the importance of close speed regulation and the effect of electric drive thereon.

*Discussion*, pp. 423-427, by Messrs. Albert Milnow, Charles F. Scott, W. S. Lee, A. W. Henshaw, David B. Rushmore, and L. T. Robinson.

General remarks and further information bearing on the effect of speed variations on production.

#### MOTOR APPLICATION TO MACHINE TOOLS

Charles Fair

Vol. xxix—1910, pp. 621-647

Profusely illustrated discussion of the general principles underlying the application of motors to machine tools, with special reference to the choice and installation of apparatus for various kinds of machines.

No discussion.

HYDROELECTRIC POWER AS APPLIED TO IRRIGATION

John Coffee Hays

Vol. xxix—1910, pp. 731-753

Description of a large ground water system of irrigation (Mount Whiting Power Company in California) operated with hydro-electric energy, covering the power equipment; forms of contracts and charges; load characteristics; power requirements for different classes of work, and effect of irrigation on land values.

*Discussion*, pp. 754-764, by Messrs. L. B. Stillwell, E. W. Paul, J. C. Hays, F. V. Henshaw, H. Homberger, L. Jorgensen, Ralph W. Pope, Markham Cheever, A. J. Bowie, Jr., W. A. Doble, and F. G. Baum.

General discussion of the relative advantages of construction having limited life and construction which is practically permanent, also general remarks on irrigation.

## 21. TELEPHONY AND TELEGRAPHY

### A. GENERAL THEORY

#### INDUCTIVE DISTURBANCES IN TELEPHONE LINES

Louis Cohen

Vol. xxvi—1907 pp. 1155-1167

Mathematical development of general equations for calculating the effects of electromagnetic induction, followed by equations for the special case of two parallel telephone circuits.

No discussion.

#### TELEGRAPH AND TELEPHONE SYSTEMS AS AFFECTED BY ALTERNATING-CURRENT LINES

John B. Taylor

Vol. xxviii—1909, pp. 1169-1215

Theoretical and experimental investigation of electrostatic and electromagnetic disturbances caused in various types of telephone and telegraph systems by different kinds of alternating-current transmission and distribution systems.

*Discussion*, pp. 1216-1252, by Messrs. L. B. Stillwell, Charles F. Scott, A. W. Copely, W. S. Murray, Charles P. Steinmetz, L. C. Nicholson, J. C. Barclay, A. L. Cook, Frank F. Fowle, and A. S. Richey.

Experience in operation of telephone and telegraph lines paralleling high-tension transmission lines and single-phase railways, and results obtained with neutralizing apparatus.

### B. TELEPHONE SYSTEMS

#### ELECTRICITY IN THE SIGNAL CORPS

Lieut. Col. Samuel Reber

Vol. xix—1902, pp. 707-724

Scope of the duties of the Army Signal Corps. Telegraph and telephone construction in the field and in fortresses. Detailed description of signal apparatus used in the army.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

#### THE TELEPHONE SWITCHBOARD

Chas. F. Scott

Vol. xxi—1903, pp. 1-2

#### THE EVOLUTION OF THE TELEPHONE SWITCHBOARD.

William D. Lockwood

Vol. xxi, 1903, pp. 3-30

Historical outline of the development of the standard relay switchboard, with description of the circuits and mode of operation at different stages of development from 1877 to date.

*Discussion*, incorporated with that of paper by William J. Hammer on "An Automatic Telephone Operator."

## AN AUTOMATIC TELEPHONE OPERATOR

William J. Hammer

Vol. xxi—1903, pp. 31-54

Description of Connolly & McTighe automatic telephone system, comparing the apparatus and mode of operation with the manual system.

*Discussion* (including that of paper by William D. Lockwood on "The Evolution of the Telephone Switchboard"), pp. 55-71 and 84-92, by Messrs. Charles F. Scott, William D. Lockwood, Samuel Sheldon, J. J. Carty, F. A. Pickernell, Bancroft Gherardi, E. F. Sherwood, G. C. Allen, F. E. Kinsman, S. P. Grace, Charles Bradley, P. M. Lincoln, L. J. Gallagher, and L. Homiwel.

General remarks on manual telephone exchange operation-service quality tests in New York; functions of telephone system compared with those of electric light plant; instruction of telephone operators; wire plant operation. Advantages of common battery over magneto telephone system. Simplification of standard relay board.

## SOME FEATURES OF TELEPHONE TRAFFIC AND THEIR EFFECT ON SERVICE

J. G. Wray

Vol. xxi—1903, pp. 73-80

Outline of the factors essential to good telephone service. Part played by the subscriber in determining quality of service, analysis of the traffic load curve in Chicago and other large cities. Efficiency of telephone plant.

No discussion.

## CONCERNING THE TELEPHONE ENGINEER

S. G. McMeen

Vol. xxi—1903, pp. 81-83

## THE ARCOPHONE

R. A. L. Snyder

Vol. xxi—1903, pp. 93-95

Brief description of the development and theory of the speaking arc, with experimental demonstration.

No discussion.

## TELEPHONE ENGINEERING

J. J. Carty

Vol. xxv—1906, pp. 81-105

Description of functions of telephone engineer. Character and scope of telephone engineering. General outline of methods of telephone plant development in large city. Relation of commercial policy to telephone engineering.

*Discussion*, pp. 106-112, by Messrs. Thomas D. Lockwood, S. S. Wheeler, Bancroft Gherardi, and C. P. Steinmetz.

Some features of early telephone plant operation. Functions of traffic engineer.



**UNDERGROUND TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY**

Charles E. Phelps

Vol. xxvi—1907, pp. 25-30

Classification of cable faults, followed by seven-year record of the performance of various kinds of power, telephone and telegraph cables. Brief analytical discussion of the causes and remedies for these various faults.

No discussion.

**THE TELEPHONE WIRE PLANT**

Sergius P. Grace

Vol. xxvi—1907, pp. 569-595

General remarks on method of laying out telephone wire plant so as to serve a growing community in the most efficient and economical manner. Details and sketch of cable terminals, wire fastenings, pole tops, etc.

*Discussion*, pp. 596-603, by Messrs. John J. Carty, Hammond V. Hayes, G. M. Yorke, F. L. Gilman, and Kempster B. Miller.

Extent of wire plant of New York Telephone Company. Stages of cable development that led up to lead covered paper insulated cable.

**A STUDY OF MULTI-OFFICE AUTOMATIC SWITCHBOARD TELEPHONE SYSTEMS**

W. Lee Campbell

Vol. xxvii—1908, pp. 503-541

Comparative study of the automatic and the manual telephone systems, with respect to cost, flexibility, wire efficiency, maintenance, depreciation and business expansion.

*Discussion*, pp. 542-551, by Messrs. A. B. Smith, John Wicks, E. A. Mellinger, Morgan Brooks, L. E. Hurtz, Samuel G. McMeen, and W. Lee Campbell.

General remarks on the multi-office system for both manual and automatic telephones. Data and experience from practice with automatic sub-stations without attendants.

**METHODS FOR LOCATING TRANSPOSITIONS OF WIRES AND SPLIT PAIRS IN TELEPHONE AND TELEGRAPH CIRCUITS**

Henry W. Fisher

Vol. xxvii—1908, pp. 1721-1732

Derivation of capacity formulas for locating faults due to transposition of wires. Comparison of results of tests using these formulas with actual distances.

No discussion.

**THE MODERN TELEPHONE CABLE**

Frank B. Jewett

Vol. xxviii—1909, pp. 1079-1093

Outline of essential requirements of telephone cables as to general construction, materials, and electrical and mechanical properties.

No discussion.

## A MODERN AUTOMATIC TELEPHONE APPARATUS

W. Lee Campbell

Vol. xxix—1910 pp. 55-84

Description of the construction and mode of operation of the Strowger automatic telephone system.

*Discussion*, pp. 85-106, by Messrs. William Maver, Ralph W. Pope, E. A. Mellinger, E. L. Lehman, Charles A. LeQuesne, Jr., A. R. Sawyer, L. C. Tomlinson, H. A. Robbins, and W. Lee Campbell.

General discussion of the operative characteristics of automatic telephony, including data on cost of maintenance and depreciation.

## THE AUTOMATIC TELEPHONE IN RELATION TO CITY SERVICE

Arthur Bessey Smith

Vol. xxix—1910 pp. 1357-1378

Description of the general features of the San Francisco & Oakland automatic telephone system from the operating standpoint, with special reference to rapid-fire suburban toll service, with method of checking back; metered and pre-payment service, and inter-connection of two-wire and three-wire exchanges.

*Discussion*, pp. 1379-1384, by Messrs. Frank F. Fowle, George D. Shepardson, L. M. Antoine, and A. B. Smith.

General remarks on the advantages of the automatic telephone system.

## C. TELEGRAPH SYSTEMS

## A NEW PAGE PRINTING TELEGRAPH

William B. Vansize

Vol. xviii—1901, pp. 7-29

Brief mention of men that have contributed to the development of printing telegraphy. Detailed description of the Murray page printer. Construction fully illustrated.

*Discussion*, pp. 30-43, by Messrs. George T. Hanchett, William B. Vansize, Carl Hering, F. B. Herzog, F. V. Henshaw, A. C. Crehore, Hollon C. Spaulding, William Mawer, Jr., Donald Murray, and Francis W. Jones.

Additional data on operation of the Murray printer.

## ELECTRICITY IN THE SIGNAL CORPS

Lieut. Col. Samuel Reber

Vol. xix—1902, pp. 707-724

Scope of the duties of the Army Signal Corps. Telegraph and telephone construction in the field and in fortresses. Detailed description of signal apparatus used in the army.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

## THE TELAUTOGRAPH

James Dixon

Vol. xxiii—1904, pp. 645-655

Description of the development, construction, operation and application of the Gray writing telegraph.

*Discussion*, pp. 656-657, by Messrs. F. C. Bates, C. O. Mailloux, James Dixon, E. B. Fahnestock, A. C. Crehore, and Townsend Wolcott.

Operation of telautograph—limiting distance, effect of line leakage and mechanical vibration.

#### UNDERGROUND TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY

Charles E. Phelps

Vol. xxvi—1907 pp. 25-30

Classification of cable faults, followed by seven-year record of the performance of various kinds of power, telephone and telegraph cables. Brief analytical discussion of the causes and remedies for these various faults.

No discussion.

#### THE ROWLAND TELEGRAPHIC SYSTEM

Louis M. Potts

Vol. xxvi—1907, pp. 507-538

Description of the theory of operation, construction and practical application of the Rowland printing telegraph.

*Discussion*, pp. 539-554, by Messrs. Ralph W. Pope, A. E. Kennelly, William Maver, Jr., Henry G. Stott, E. F. Northrup, Gano Dunn, and Sir William Preece.

Early experiences in the telegraph field and reminiscences of Rowland, Edison and Faraday.

#### AMERICAN TELEGRAPH ENGINEERING—NOTES ON HISTORY AND PRACTICE

William Maver, Jr. and Donald McNicol

Vol. xxix—1910, pp. 1303-1338

Brief historical résumé of American telegraph practice, followed by short discussion of some of the most salient features of present day practice, such as: Sources of e. m. f.; printers; super-imposed systems; inductive disturbances; testing; aerial *vs.* underground lines. Suggested plan for housing in telegraph lines for protection from storms.

*Discussion*, pp. 1339-1356, by Messrs. William Maver, Jr., Ralph W. Pope, John B. Taylor, Gano Dunn, William B. Hale, G. A. Cellar, Louis M. Potts, W. J. Camp, F. W. Jones, Donald McNicol, and Charles F. Scott.

Remarks on telegraph practice in United States, Mexico and Europe. Opinions as to the requirements of the ideal telegraph system.

#### D. WIRELESS SYSTEMS

##### ANNUAL DINNER OF AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Guest of Honor, Guglielmo Marconi

Vol. xix—1902, pp. 93-121

Description of the present status of achievement with Marconi system. Evolution of the wireless from wire telegraph system explained with the help of diagrams.

## WIRELESS TELEGRAPHY IN THE UNITED STATES NAVY

Lieut. A. M. Beecher

Vol. xix-1902, pp. 569-578

Description of the general principles of wireless telegraph systems and account of what has actually been done in the navy.

*Discussion*, incorporated with that of paper by Louis Bell on "Emergency Engineering for Harbor Defence."

## THE AUDION

Lee DeForrest

Vol. xxv-1906, pp. 735-736

Account of the inception and development of vacuum tube hot-electrode wave detector and theoretical discussion of the conduction of electricity through heated vapors and gases, with much experimental data and frequent references to the work of others.

*Discussion*, pp. 764-779, by Messrs. Michael I. Pupin, Percy H. Thomas, Lee DeForrest, Sewall Cabot, J. B. Taylor, Edward P. Thompson, Frederick K. Vreeland, C. D. Ehret, W. E. S. Temple, H. C. Snook, E. F. Northrup, James Haywood, and George Breed.

Hittorf's discovery of the effect on conduction through gases in vacuum tube of heating the electrode. Nature of ions and corpuscles. Explanation of operation of audion by accoustical theory. Analogy between audion and polariphone (electrolytic wave detector). Difference between Fleming rectifier and audion.

## WIRELESS TELEGRAPH RECEIVERS

S. M. Kintner

Vol. xxv-1906, pp. 781-787

General remarks on wave detectors invented by Professor Fessenden—hot wire and liquid barretters.

No discussion.

## WIRELESS TELEPHONY

R. A. Fessenden

Vol. xxvii-1908, pp. 553-629

Brief history of the development of wireless signalling with numerous references to the original documents. Account of author's invention of wireless telephony and subsequent work. Short description of the different types of wireless telephone apparatus. Results of experiments on atmospheric absorption of waves, together with forecast of future of wireless telephony. Long account of how wireless telegraph has been hampered by governmental action. Numerous quotations.

No discussion.

## 22. MISCELLANEOUS TOPICS

### A. INSTITUTE AFFAIRS

#### ANNUAL REPORTS

Vol. xviii—1901, pp. 207-218  
Vol. xix—1902, pp. 487-497  
Vol. xxi—1903, pp. 479-486  
Vol. xxiii—1904, pp. 807-838  
Vol. xxiv—1903, pp. 1120-1151  
Vol. xxv—1906, pp. 927-943  
Vol. xxvi—1907, pp. 891-909  
Vol. xxvii—1908, pp. 1743-1761  
Vol. xxviii—1909, pp. 1503-1520  
Vol. xxix—1910, pp. 1730-1747

#### PRESIDENTIAL ADDRESSES

Charles P. Steinmetz

Vol. xix—1902, pp. 1145-1150

Description of the shortcomings in present methods of teaching engineering in colleges. Outline of an ideal course in electrical engineering.

*Discussion*, incorporated with that of paper by E. B. Raymond on "Proposed Reform in Technical Training."

Charles F. Scott

Vol. xxii—1903, pp. 3-15

Brief discussion of the status of the Institute. The age and occupation of its members. An outline of plans for the development of the usefulness of the Institute, and definite proposal for carrying out this work of development.

No discussion.

Bion J. Arnold

Vol. xxiii—1904, pp. 615-623

Brief sketch of electric railway development since 1893. Present prospects of electric locomotives supplanting steam locomotives. Dividing line between steam and electric trunk line operation.

*Discussion*, pp. 624-644, by Messrs. Charles P. Steinmetz, — Gray, John Perry, B. G. Lamme, C. V. Drysdale, B. J. Arnold, F. J. Sprague, and Elihu Thomson.

The requirements of different classes of railway service—city, suburban, and interurban passenger and freight trunk line, and mountain service. Speed torque characteristics of various types of railway motors, single-phase, polyphase and direct-current, and discussion of their proper spheres of application. Development and application of single-phase compensated series motor. Methods of control. Invention of the repulsion motor.

PRESIDENTIAL ADDRESSES—(*Continued*)

John W. Lieb, Jr.

Vol. xxiv—1905, pp. 283-286

General review of the practices of the National Engineering Societies of the United States and Europe, with special reference to requirements for membership, expenses and disbursements per member, administration, standing committees, local branch organizations, etc.

No discussion.

Schuyler Skatts Wheeler

Vol. xxv—1906, pp. 241-266

General outline of moral duties of electrical engineers. Abstract of codes of ethics in various professions—ministry, law, medicine, architecture and engineering.

*Discussion*, pp. 266-268, by Messrs. C. P. Steinmetz, Dugald C. Jackson, S. S. Wheeler, and C. F. Scott.

Motion made and passed to nominate committee to consider drafting of code of ethics.

Samuel Sheldon

Vol. xxvi—1907, pp. 937-968

Conception of electrons and brief exposition of their properties. Application of electronic theory to the explanation of the fundamental principles of electrophysics—conduction of electricity in gases, vapors and solids; contact, thermal and electromagnetic generation of e. m. f., dielectric phenomena; radiation and luminescence.

No discussion.

Henry Gordon Stott

Vol. xxvii—1908, pp. 459-464

Definition of engineering. The part that the engineer should play in public life.

No discussion.

Louis A. Ferguson

Vol. xxviii—1909, pp. 355-361

Financial, technical and industrial advantages of centralization of electrical energy production.

No discussion.

Lewis B. Stillwell

Vol. xxix—1910, pp. 1037-1052

Discussion and criticism of Government's water power conservation policy, with suggested plan of water power control.

No discussion.

## MISCELLANEOUS AFFAIRS

## REPORT OF THE COMMITTEE ON STANDARDIZATION

Vol. xix—1902, pp. 1075-1091

*Discussion*, p. 1092, by Messrs. Chas. P. Steinmetz, F. A. C. Perrine and William Stanley.

## PROPOSED DEVELOPMENT OF THE INSTITUTE

Chas. F. Scott

Vol. xx—1902, pp. 1-14

Outline of the functions of the Institute and brief description of the plans for future development.

No discussion.

## LIBRARY DINNER OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Vol. xxi—1903, pp. 97-108

Speeches by Messrs. Chas. F. Scott, T. C. Martin, S. S. Wheeler, Andrew Carnegie, J. S. Billings, R. R. Bowker, Theodore L. DeVinne, and Jas. C. Bayles.

## ENGINEERING SOCIETIES' BUILDINGS

Vol. xxi—1903, pp. 479-496

Annual report of Board of Directors and resolutions in regard to Engineering Societies' Building.

INSTITUTE BRANCH MEETINGS. THEIR ORGANIZATION, DEVELOPMENT  
AND INFLUENCE

Calvin W. Rice

Vol. xxii—1903, pp. 63-66

*Discussion*, pp. 67-70, by Messrs. Charles F. Scott, Harris J. Ryan, W. E. Goldsborough, Peter Junkersfeld, and Ralph W. Pope.

General remarks on the work of the branches.

## DISCUSSION ON "LOCAL ORGANIZATION" AT MILWAUKEE, WISCONSIN

Vol. xxv—1906, pp. 649-659

By S. S. Wheeler, C. P. Steinmetz, C. F. Scott, Geo. O. Squier, Kempster B. Miller, and Samuel Sheldon.

Discussion on local organizations. Experiences with branches and opinions as to the desired policy of the Institute with regard to local organizations.

## THE WORK OF THE INSTITUTE

Samuel Sheldon

Vol. xxv—1906, pp. 661-669

Outline and scope of work of the Institute, its officers and its committees.

No discussion.

## PROPOSED CODE OF ETHICS

Vol. xxvi—1907, pp. 1421-1425

*Discussion*, pp. 1426-1428, by Messrs. Schuyler S. Wheeler, William McClellan, Henry G. Stott, and H. W. Buck.

Criticism of some of the proposed rules. Motion carried to refer Code of Ethics to Board of Directors.

## B. CONSERVATION OF NATURAL RESOURCES

THE PRESERVATION OF THE SOUTHERN APPALACHIAN STREAMS.  
A FOREST PROBLEM

Charles Edward Waddell

Vol. xxiv—1905, pp. 889-892

Brief characterization of the water shed. Extent of erosion due to floods. Action of forests in stream preservation.

No discussion.

## CONSERVATION OF POWER RESOURCES

H. St. Clair Putnam

Vol. xxvii—1908, pp. 377-396

Statistical study of the natural sources of energy in the United States and their utilization, showing their extent, value and method of use.

No discussion.

## WATER POWER DEVELOPMENT IN THE NATIONAL FORESTS. A SUGGESTED GOVERNMENT POLICY

Frank G. Baum

Vol. xxvii—1908, pp. 475-484

A plan for controlling the development of water power and a method of fixing and utilizing the conservation charges.

*Discussion*, pp. 405-502, by Messrs. J. H. Finney, E. R. Taylor, T. P. Wells, A. H. Babcock, H. G. Stott, C. P. Steinmetz, William McClellan, C H. Porter, and J. A. Britton.

Criticisms of Mr. Baum's plan. Outline of the Forest Service policy and general discussion of the problem of conservation of water power as a national asset.

## ELECTRICITY AND THE CONSERVATION OF ENERGY

Lewis B. Stillwell

Vol. xxviii—1909, pp. 163-178

Analytical discussion of the problem of conserving natural resources, with special reference to the part played by water power companies and central electric stations. Statistics.

*Discussion*, pp. 179-187, by Mr. John Coffee Hays.

Water power rights and conservation of natural resources in California. Suggested control of Government water power grants.

## CONSERVATION OF WATER POWERS

Lewis B. Stillwell

Vol. xxix—1910, pp. 1037-1052

Discussion and criticism of Government's water power conservation policy, with suggested plan of water power control.

No discussion.

## C. GENERAL SUBJECTS

## IMPORTANT EUROPEAN ELECTRICAL AND ENGINEERING DEVELOPMENTS AT THE CLOSE OF THE NINETEENTH CENTURY

William J. Hammer

Vol. xviii—1901, pp. 47-122

General description of Poulsen's Telephonograph; Engen-Langen suspended monorail railway; Nernst lamps, Osmium lamps; gas engines for blast furnace gas and producer gas; sulphur dioxide or binary engine; trackless trolley bus; electric plough; experimental three-phase railways at Alte-Ofen and at Grosse Lichterfelde; Jungfrau railway.

No discussion.



## COLLOIDS

W. R. Whitney

Vol. xix—1902, pp. 343-352

Comparison of the characteristics of colloidal and ordinary solutions. Discussion of the theory of colloidal precipitation and other properties of colloids.

*Discussion* (including that of paper by Samuel Sheldon on "The Electro-Chemical Industries;" paper by Chas. B. Jacobs on "The Electric Furnace in Industrial Chemistry;" paper by Carl Hering on "The Electrolytic Conduction without Electrodes;" paper by Carl Hering on "Liquid Potentiometer; Determining Electrolytic Resistances with Direct-Current Instruments;" paper by Carl Hering on "Point of Cutoff in a Battery Discharge;" and paper by N. S. Keith on "Electrolytic Recovery of Copper from Low-Grade Ores"), pp. 351-372, by Messrs. C. P. Steinmetz, Maurice LeBlanc, Chas. S. Bradley, C. A. Doremus, N. S. Keith, W. R. Whitney, Edward P. Thompson, C. J. Reed, Carl Hering, Samuel Sheldon, Chas. B. Jacobs, and C. F. Burgess.

General discussion of the theory of colloids from both electrical and mechanical viewpoints. Application of the theory of evolution to development of an electro-chemical process.

## THE ENGINEER OF THE TWENTIETH CENTURY

Chas. F. Scott

Vol. xx—1902, pp. 301-306

Response to a toast at the 25th anniversary banquet of the Engineers' Club of Philadelphia.

## RADIOACTIVE SUBSTANCES

Vol. xxi—1903, pp. 327-327

Introduction by President Chas. F. Scott.

RADIUM AND OTHER RADIOACTIVE SUBSTANCES WITH A CONSIDERATION OF PHOSPHORESCENT AND FLUORESCENT SUBSTANCES. THE PROPERTIES AND APPLICATION OF SELENIUM AND THE TREATMENT OF DISEASE BY THE ULTRAVIOLET LIGHT

William J. Hammer

Vol. xxi—1903, pp. 331-402

General discourse on luminous and chemical radiations and some practical applications of these forms of energy. Historical notes on the development of the various branches of these sciences and short description of much of the original work.

No discussion.

## THE ART OF INVENTING

Edwin J. Prindle

Vol. xxv—1906, pp. 519-541

Inventing as a profession; classification of inventions; examples of mode of procedure in evolving certain inventions.

*Discussion*, pp. 542-547, by Messrs. C. P. Steinmetz, S. S. Wheeler, and Edwin J. Prindle.

## DEFLOCCULATED GRAPHITE

Edward G. Acheson

Vol. xxvi—1907, pp. 1363-1366

Brief description of the development of a process of producing deflocculated graphite which will remain suspended in water or oil indefinitely.  
No discussion.

THE ENGINEER'S ACTIVITY IN PUBLIC AFFAIRS PUBLIC UTILITY COMMISSION  
AND FRANCHISE VALUATIONS

Henry Floy

Vol. xxvii—1908, pp. 335-353

General discussion of the importance of the engineer in commercial affairs with a brief review of his limitations. Constitution of Public Service Commissions and the scope of their work. Discussion of franchise valuation advocating special systems suggested by the author.

*Discussion*, pp. 354-372, by Messrs. George S. Coleman, Chas. F. Lacombe, H. M. Brinckerhoff, Louis A. Ferguson, Henry L. Doherty, W. W. Freeman, and Henry Floy.

General remarks on Public Service Commissions—franchise valuation "fair return" on investment.

THE EVOLUTION OF ENGINEERING  
PRESIDENT'S ADDRESS

Henry Gordon Stott

Vol. xxvii—1908, pp. 459-464

Definition of engineering. The part that the engineer should play in public life.

No discussion.

ELECTRICITY AS VIEWED BY THE INSURANCE ENGINEER; SHOULD THE A. I. E. E.  
INTEREST ITSELF IN FIRE PROTECTION

C. M. Goddard

Vol. xxvii—1908, pp. 467-472

Statistics of the fire loss in the United States. Outline of the work of the fire protection engineer, bringing out the need of the co-operation of the Institute with the National Fire Protection Association.

*Discussion*, p. 473, by Mr. Chas. P. Steinmetz.

THE PATENT SYSTEM AND ITS RELATION TO INDUSTRIAL DEVELOPMENT  
Frederick P. Fish

Vol. xxviii—1909, pp. 315-339

Historical résumé of the development of the patent system. General discussion of the United States Patent Law, together with classification of inventors and inventions. Methods of compensating inventors.

*Discussion*, pp. 340-353, by Messrs. Francis B. Crocker, Albert G. Davis, Arthur Von Briesen, Thomas B. Kerr, Livingston Gifford, E. W. Rice, Jr., and Charles P. Steinmetz.

General discussion of the United States patent situation from various standpoints.

# TOPICAL INDEX

Acceleration	curves, plotting .....	XIX (02)	918
	effect on train load curve.....	XXIV (05)	475
	energy, equation .....	XXII (03)	148
	saving due to rapid.....	XXIX (10)	1466
	losses, railway motors, calculation.....	XXII (03)	670
	maximum through, in terms of initial....	XIX (02)	134
	measurement, railway tests .....	XXV (06)	512
	service .....	XXII (03)	559
	motor curve energy equation.....	XXII (03)	148
	practice in electric traction.....	XXIV (05)	558
	railway service, choice .....	XIX (02)	821
	three-phase locomotive .....	XIX (02)	521
	motor .....	XVIII (01)	325
	through, definition .....	XIX (02)	133
train, actual curves .....	XXIII (04)	726	
	calculations .....	XIX (02)	137
	different classes of service.....	XXIV (05)	529
	distance equations .....	XIX (02)	146
	economy of high values...XIX (02)	188, 192,	194
	energy classification .....	XIX (02)	909
	equations .....	XIX (02)	146
	equations .....	XIX (02)	137
	formulas, derivation .....	XIX (02)	976
	limitation tests .....	XXIII (04)	728
	power equations .....	XIX (02)	146
	required for different rates..	XIX (02)	156
	tests, canal boat haulage.....	XXVII (08)	287
	railway, measurement .....	XXV (06)	512
	limiting values .....	XXIII (04)	728
	tilting action on trailer cars, tests.....	XXIX (10)	1457
Accuracy, commercial limits .....	XX (02)	87	
	construction of electric machinery.....	XXIV (05)	685
	mine hoists, calculation .....	XXIX (10)	295
	hot-wire comparator .....	XXIV (05)	755
Acetylene burner, construction .....	XIX (02)	52	
	flame, luminous intensity .....	XIX (02)	53
	spectrophotometric measurements ....	XIX (02)	54
Actinium, discovery .....	XXI (03)	346	
Acyclic generators (see Generators).			
Adams method, calculating a. c. generator regulation....	XXIII (04)	324	
	alternator wave shape .....	XXVIII (09)	1069
Adhesion coefficient electric locomotives.....	XXVI (07)	1647	
	practice .....	XXVI (07)	1678
	steam locomotive .....	XXVI (07)	1647
	practice .....	XXVI (07)	1678
Admittance formula, multiple circuits.....	XXVII (08)	1397	
Air, conductance .....	XXVIII (09)	802	
	conductivity, thermal .....	XXIV (05)	403
	corona phenomena (also see Corona).....	XXIX (10)	1159
	critical corona voltage, formula.....	XXIX (10)	1231
	intensity about a conductor, measurement	XXIX (10)	1162
	dielectric properties, bibliography .....	XXIX (10)	1187
	study .....	XXIX (10)	1159

Air, dielectric ( <i>continued</i> )		
strains about grounded wires.....	xxvi (07)	875
transmission towers .....	xxvi (07)	880
strength....xxiii (04) 108; xxviii (09)	772, 799,	803
effect of electrode surface cur- vature .....	xxix (10)	1213
transient e. m. f. ....	xxix (10)	1131
disruptive energy .....	xxix (10)	1151
ionization preceding breakdown .....	xxix (10)	1160
liquefaction .....	xxiv (05)	1018
spark discharge, explanation .....	xxix (10)	1227
striking distance, infinite transient e. m. f.....	xxix (10)	1143
Air-gap alternators, engine driven.....		
effective, effect of slot form.....	xxviii (08)	153
generators, Niagara No. 1.....	xviii (01)	479
motor induction .....	xxiii (04)	2
calculation .....	xxiv (05)	656
railway .....xix (02) 550;	xxiv (05)	546
Ganz & Co. ....	xviii (01)	105
Siemens & Halske..	xviii (01)	113
selection .....	xxiv (05)	676
repulsion .....	xxiii (04)	2
Alexanderson self-exciting alternator .....		
single-phase railway motor .....	xxv (06)	61
Alkalies, electrolytic separation process.....	xxvii (08)	1
Alloys, magnetic, non-ferrous .....	xix (02)	285
Aluminium, advantages as line conductor.....	xxv (06)	468
cell (see Cell).	xxiii (04)	535
coefficient of expansion .....	xxiii (04)	514
elastic limit of cable.....	xxiii (04)	514
electrolytic reduction .....	xix (02)	286
modulus of elasticity of wire.....	xxiii (04)	514
tensile strength of wire.....	xxiii (04)	514
A. I. E. E. age requirements for full membership.....		
branches, general remarks on work.....	xxiv (05)	288
date of organization .....	xxii (03)	63
entrance fees and dues.....	xxiv (05)	284
functions .....	xxiv (05)	290
ideals .....	xx (02)	7
local organizations, discussion .....	xxii (03)	5
members, average age .....	xxv (06)	649
training .....	xxii (03)	6
occupations .....	xxii (03)	6
positions .....	xxii (03)	7
organization .....	xxv (06)	661
receipts and disbursements per member....	xxiv (05)	291
scope of work .....	xxv (06)	661
A. I. M. E., date of organization.....		
entrance fees and dues.....	xxiv (05)	284
receipts and disbursements per member....	xxiv (05)	290
American Nettie Gold Mine, Colorado, electric plant...		
date of organization.....	xviii (01)	193
A. S. C. E., date of organization.....		
entrance fees and dues.....	xxiv (05)	284
receipts and disbursements per member....	xxiv (05)	290
A. S. M. E., date of organization.....		
entrance fees and dues.....	xxiv (05)	291
receipts and disbursements per member....	xxiv (05)	290
receipts and disbursements per member....	xxiv (05)	291

Ammeter a. c. calibration with hot-wire comparator....	XXIV (05)	746
Armstrong recording .....	XXII (03)	689
inductance measurements .....	XXV (06)	720
Ammunition, handling, motor requirements.....	XIX (02)	682
Andrews differential choke coil, connection diagram....	XXII (03)	308
prevention, power re-		
versal .....	XXII (03)	307
reverse current indicator .....	XXII (03)	306
Anemometry, application of forced convection law for		
electric conductors .....	XXVIII (09)	388
Audion, acoustical theory .....	XXV (06)	770
life .....	XXV (06)	762
theory of operation .....	XXV (06)	755
Animas Power & Water Co. lightning arrester equip-		
ment, descrip-		
tion .....	XXVII (08)	701
tests .....	XXVII (08)	691
Anti-surgng device for engine governors.....	XVIII (01)	747
Appalachian Mts., minimum flow period.....	XXIV (05)	792
principal rivers .....	XXIV (05)	793
rainfall .....	XXIV (05)	791
southern slopes, drainage area.....	XXIV (05)	890
estimated power....	XXVII (08)	380
rainfall .....	XXIV (05)	890
temperature range	XXIV (05)	802
water-shed, erosion	XXIV (05)	890
Applegate static pick-up, for preventing inductive dis-		
turbances in telegraph lines.....	XXIX (10)	1326
Apprenticeship course, General Electric Co. ....	XXVII (08)	1462
Arc, carbon, e. m. f. equation.....	XXV (06)	803
enclosed, e. m. f. wave .....	XXIV (05)	882
maximum temperature .....	XXV (06)	791
open, e. m. f. wave .....	XXIV (05)	883
volt-ampere characteristic .....	XXV (06)	804
characteristics as illuminant .....	XXV (06)	809
circuits (see Circuits).		
conduction theory .....	XXV (06)	802
crater, intrinsic brilliancy.....	XX (02) 72; XXVI (07)	628
devices for suppressing .....	XXVI (07)	1086
electric, characteristics .....	XXIV (05)	371
flame characteristics .....	XXV (06)	811
high-tension, photographs .....	XXVI (07)	852
inverted .....	XIX (02)	83
lamps (see Lamps, arc).		
magnetite, e. m. f. equation .....	XXV (06)	803
volt-ampere characteristic .....	XXV (06)	804
mercury e. m. f. equation .....	XXV (06)	628, 805
methods of starting .....	XXV (06)	630
operation theory .....	XXV (06)	601
rectification properties, first description	XXIV (05)	395
rectifier, mode of operation.....	XXIV (05)	373
spectrum .....	XXV (06)	631
theory .....	XXV (06)	796
volt-ampere characteristic .....	XXV (06)	627
rectifying action .....	XXV (06)	806
self-rupturing characteristics .....	XXIV (05)	367
short circuit, oscillations produced by rupture....	XVIII (01)	386
speaking, development .....	XXI (03)	93

- Arc, speaking, (*continued*)  
     theory .....XXI (03) 94  
     use of selenium .....XXI (03) 374
- Arcing ground (see Ground).  
     rings performance in protection of insulators...XXIX (10) 610, 619  
     protection of insulators, tests.....XXIX (10) 593
- Arcophone description .....XXI (03) 93
- Armature a. c., 10,000 cycles, construction.....XXIII (04) 419  
     generator, cost .....XXVIII (09) 980  
         inductance observed .....XXIII (04) 327  
     inductance, calculation .....XXIII (04) 302  
     low-speed, current density .....XXII (03) 47  
     magnetic circuits .....XXIII (04) 292  
     m. m. f., effect on flux distribution.....XXIII (04) 295  
     windings, classification .....XXVIII (09) 1054
- conductors, eddy-current loss factors for  
     different slot arrangements...XXIV (05) 772  
     laminations, effect upon eddy  
         currents .....XXIV (05) 770  
         magnitude of eddy currents.....XXIV (05) 762  
         reactance, calculation .....XXIV (05) 777  
     d. c., method of design.....XXIV (05) 702
- humming, elimination by beveling poles.....XXV (06) 345
- iron losses, analyses .....XXII (03) 450  
     effect of laminating poles.....XXII (03) 459  
         number of poles...XXII (03) 458, 462  
         teeth .....XXII (03) 454  
     experimental investigation .....XXII (03) 445  
     in teeth .....XXVIII (09) 997  
     relation to frequency .....XXII (03) 454
- laminations, methods of support.....XXIII (04) 262  
     thickness .....XXIII (04) 263
- reaction, action of pole-face winding.....XXVII (08) 152  
     acyclic generators .....XXIV (05) 22  
     calculation .....XXIII (04) 306  
     compensation in Alexanderson self-  
         exciting alternator .....XXV (06) 71  
     d. c. machines, maximum permissible...XXIV (05) 700  
     effect of chorded winding.....XXVII (08) 1080  
         on division of load between  
             generators .....XXVIII (01) 755  
             generator efficiency .....XXVII (08) 1086  
     generator, acyclic .....XXIV (05) 22  
     split-pole converters .....XXVII (08) 1051  
     synchronous converters...XXIV (05) 734  
         effect on e.m.f.  
             wave .....XXII (03) 30  
             high vs. low...XXVII (08) 196
- slot profiles, typical .....XXIII (04) 263
- smooth, paths of flux.....XXVIII (09) 994
- teeth, iron losses .....XXVII (09) 997
- toothed, paths of flux.....XXVIII (09) 996
- ventilating space blocks, typical.....XXIII (04) 265
- windings (see Windings).  
     choice for wave shape.....XXVIII (09) 1076
- Armstrong recording instrument for railway tests.....XXII (03) 689
- Army, cable specifications .....XIX (02) 681  
     first application of telegraph under war conditions...XIX (02) 708

Army, ( <i>continued</i> )			
Signal Corps, duties .....	XIX (02)	707	
field search light description.....	XIX (02)	718	
telegraph apparatus, descrip- tion .....	XIX (02)	710	
telephone kit, description.....	XIX (02)	715	
uses of electricity .....	XIX (02)	559	
Arnold, electro-pneumatic single-phase railway system.....	XIX (02)	1003	
Arno's tangent phase meter, mode of operation.....	XVIII (01)	297	
Asbestos, heat conductivity method of improving.....	XXIII (04)	477	
Asphaltum, conductivity, thermal .....	XXIV (05)	403	
protection of cables against electrolysis.....	XXVII (08)	1522	
against electrolysis .....	XXVII (08)	1533	
Atkinson, commutator induction motor, description.....	XXVIII (09)	475	
Atmospheric loss (see Corona).			
Atoms, nature .....	XXVI (07)	946	
Attenuation constant, telephone cables, formula.....	XXVIII (09)	1084	
traveling wave .....	XXVII (08)	1263	
Automatic telephone systems (see Telephones).			
Baltimore & Ohio, performance record of locomotives.....	XXVIII (09)	1330	
Barium cyanide, electrolytic production.....	XIX (02)	291	
hydrate, electrolytic production .....	XIX (02)	291	
Baum regulation diagram, method of using.....	XIX (02)	755	
Barretter, definition .....	XXVII (08)	563	
hot-wire, description .....	XXVII (08)	563	
liquid, description .....	XXVII (08)	563	
Battery, definition .....	XIX (02)	665	
primary, diaphragm resistance, measurement.....	XIX (02)	322	
porous cup resistance, measurement.....	XIX (02)	322	
storage, a. c. plants, examples.....	XXVII (08)	1029	
advantages in railway service.....	XXII (03)	300	
calculation, battery on line.....	XXII (03)	715	
booster in			
station ....	XXII (03)	723	
in station .....	XXII (03)	708	
booster and battery on line.....	XXII (03)	722	
in station.....	XXII (03)	720	
industrial locomotive service.....	XXII (03)	115	
carbon regulator, description .....	XXIV (05)	1089	
mode of operation.....	XXVII (08)	996	
control for locomotive service.....	XXII (03)	120	
cost .....	XX (02)	136	
disadvantages in a. c. system.....	XVIII (01)	875	
discharge curve, constant power.....	XIX (02)	329	
typical .....	XIX (02)	326	
cut-off point, determination.....	XIX (02)	325	
Edison, charge and discharge curves,			
tests .....	XVIII (01)	239	
discharge current .....	XVIII (01)	220	
curves .....	XVIII (01)	228	
e. m. f. characteristics at high			
rates .....	XXII (03)	733	
electrodes, composition .....	XVIII (01)	220	
electrolyte, composition .....	XVIII (01)	220	
energy capacity per unit			
weight .....	XVIII (01)	220	
tests .....	XVIII (01)	239	

Battery, storage, Edison, ( <i>continued</i> )		
initial e. m. f. ....	XVIII (01)	220
mean e. m. f. ....	XVIII (01)	220
charging e. m. f. ....	XVIII (01)	234
mechanical construction ....	XVIII (01)	221
objections ....	XVIII (01)	236
weight of solution ....	XVIII (01)	225
effect on load-factor, Chicago Edison Co. ....	XVIII (01)	893
efficiency in railway substation, tests ....	XXII (03)	276
with differential booster ....	XXII (03)	734
experience with differential booster ....	XXII (03)	734
equalization efficiency, definition ....	XXII (03)	253
floating, effect of resistance upon		
operation ....	XXIII (04)	458
on line, calculation ....	XXII (03)	715
power house, calculation ....	XXII (03)	708
railway circuits, calculation		
tion ....	XXIII (04)	394
Gary plant, description ....	XXVII (08)	995
interurban substation load, tests ....	XXII (03)	256
lead, chemical equations ....	XVIII (01)	225
energy capacity per unit weight ....	XVIII (01)	219
positive plate depreciation ....	XXII (03)	734
locomotive, advantages ....	XXII (03)	109
performance characteristics ....	XXII (03)	706
railway circuits, calculation ....	XXII (03)	708
location ....	XXIII (04)	396
methods of applying ....	XXII (03)	705
service, performance tests ....	XXII (03)	252
rating for telephone service ....	XXV (06)	96
regulation a. c. circuits. XXVII (08) 987; XXVIII (09) 851		
methods ....	XXVII (08)	988
operation ....	XXVIII (09)	859
characteristics ....	XXII (03)	706
renewals, cost ....	XX (02)	135
room, ventilation ....	XXVIII (09)	852
speed regulation of printing press ....	XX (02)	136
standby service, cost ....	XXVIII (09)	1417
for hydro-electric		
plants ....	XXVIII (09)	1451
steel plants, first		
in U. S. ....	XXVIII (09)	104
train lighting, cost ....	XXI (03)	176
disadvantages ....	XXI (03)	175
weights ....	XXI (03)	176
use in railway substation ....	XVIII (01)	822
on single-phase railroad system ....	XXVII (08)	992
system supplying two or more		
e. m. f's. ....	XVIII (01)	820
value in city distribution systems ....	XVIII (01)	820
Bay Counties Power Co., insulator pins, dimensions ....	XXI (03)	268
Beams, bending moment, formula ....	XXVI (07)	1224
Bearings, vertical synchronous converters, construction ....	XXVII (08)	183
thrust, oil pressure ....	XVIII (01)	476
Becquerel rays, discovery ....	XXI (03)	342
properties ....	XXI (03)	342
Behn-Eschenburg method of regulation calculation ....	XXI (03)	499



# TOPICAL INDEX

193

Behrend heat test of alternators.....	XXV	(06)	311
Bell radiophone .....	XXI	(03)	373
Berlin, central station system.....	XVIII	(01)	826
Berlin-Zossen tests, trolley construction.....	XIX	(02)	546
Bibliography, a. c. commutator motors.....	XXI	(03)	568
dielectric properties of air.....	XXIX	(10)	1187
illumination .....	XX	(02)	76
insulation and insulating materials.....	XXIX	(10)	1580
wave measurement .....	XXIV	(05)	213
Bifilar suspension, formula .....	XIX	(02)	1041
Biltmore electric heating plant, description.....	XXVII	(08)	651
Binary engines, description .....	XVIII	(01)	92
Blakeney-Chetwood device for preventing inductive dis- turbances in telegraph lines.....	XXIX	(10)	1326
Blast furnace, gas per unit output.....	XVIII	(01)	81
Bleach, electrolytic separation process.....	XIX	(02)	285
Bliss axle-driven train lighting system.....	XXI	(03)	134
Blondel oscillograph, description .....	XXIV	(05)	195
Bloom shears, a. c. motor design features.....	XXVII	(08)	332
compound motor driven, data and per- formance .....	XXVII (c8)	325, 328,	331
power requirements .....	XXVII	(08)	321
Blowers, air-blast transformers, power required.....	XXIII	(04)	236
Boats, canal, acceleration tests.....	XXVII	(08)	287
cost of haulage by mules, steam propellers and electric motors .....	XXVII	(08)	317
electric haulage, tests .....	XXVII	(08)	277
energy consumption of towing machines.....	XXVII	(08)	309
Erie steering gear, effect on water resist- ance .....	XXVII	(08)	285
power required to haul, tests.....	XXVII	(08)	285
speed limitations, mule haulage.....	XXVII	(08)	294
power haulage .....	XXVII	(08)	294
starting pull, tests .....	XXVII	(08)	287
time required for locking.....	XXVII	(08)	297
water resistance tests .....	XXVII	(08)	313
Boilers, double-grate, construction, I. R. T. Co.....	XXVI	(07)	1716
maintenance cost .....	XXVI	(07)	1718
operation cost .....	XXVI	(07)	1718
draft relation to economy.....	XXV	(06)	9
economy due to use of exhaust steam for feed water heater .....	XXIV	(05)	46
relation to draft .....	XXV	(06)	9
test, peak, double load.....	XXIX	(10)	346
normal load .....	XXIX	(10)	346
effect of increasing ratio of grate area to heat- ing surface .....	XXVI	(07)	1713
efficiency, effect of combustion rate.....	XXVI	(07)	1723, 1734
ratio of grate area to heat- ing surface .....	XXVI	(07)	1721
velocity of gases.....	XXVI	(07)	1726
relation to flue gas temperature and carbon-dioxide content .....	XXVI	(07)	1773
feed water (see Feed water).			
firing, powdered coal .....	XXVIII	(09)	1369, 1382
fuel loss, relation to carbon dioxide content.....	XXV	(06)	8

Boilers, (*continued*)

grate surface to heating surface, large installations .....	XXVII	(08)	1111
heating surface to grate surface, large installations .....	XXVII	(08)	1111
per horse-power, average .....	XXVI	(07)	1725
house, size, effect of ratio of grate area to heating surface .....	XXVI	(07)	1713
leakage, magnitude .....	XXIX	(10)	1681
losses, analysis .....	XXV	(06)	3
maintenance cost .....	XXVI	(07)	1718
operation cost .....	XXVI	(07)	1718
overload, safe .....	XXIX	(10)	346
test at double .....	XXIX	(10)	346
performance of large installations.....	XXVII	(08)	1111
plants, log of tests in large installations.....	XXVII	(08)	1111
maintenance, effect of evaporation rate.....	XXVI	(07)	1735
load-factor.....	XXVI	(07)	1711
operation charges, effect of load-factor.....	XXVI	(07)	1711
service tests .....	XXII	(03)	473
power capacity for different widths of fronts.....	XXVII	(08)	1109
ratio to turbine capacity.....	XXVII	(08)	1107
relation to normal load.....	XXIX	(10)	346
ratio grate area to heating surface, average.....	XXVI	(07)	1734
N. Y. Edison Co.....	XXVI	(07)	1725
setting, dimensions of various types.....	XXVII	(08)	1111
standby service, heat storage of electric energy.....	XXIX	(10)	678
rating required .....	XXIX	(10)	679
testing logs .....	XXII	(03)	477
water-tube, time to start.....	XXVIII	(09)	1459
Bonds, rail, classification .....	XXIV	(05)	82
cost of installation, actual.....	XXIV	(05)	89
deterioration, causes .....	XXIV	(05)	85
economical conductance, determination.....	XXIV	(05)	90, 93
inductive, effect of return current on impedance .....	XXIV	(05)	584
inspection of construction .....	XXIV	(05)	84
life .....	XXIV	(05)	88
joints, resistance .....	XXIV	(05)	88
Bonding, cable, armor and sheath to reduce impedance.....	XXVIII	(09)	755
Booster, a. c. advantages .....	XXVII	(08)	231
inventor .....	XXVII	(08)	245
calculations for railway circuits.....	XXII	(03)	720
carbon regulator, description .....	XXIV	(05)	1089
differential, experience .....	XXII	(03)	734
railway battery service, tests.....	XXII	(03)	254
storage battery, classification .....	XXII	(03)	719
Boston Edison Co., L street station, description.....	XXIV	(05)	30
Elevated, signal system .....	XXIV	(05)	580
Braid insulation, resistivity, thermal.....	XXVI	(07)	982
Brakes, air, automatic, development.....	XX	(02)	236
early application of electric valves.....	XX	(02)	299
effect on energy consumption of car.....	XX	(02)	280
beams, under-hung, advantages .....	XX	(02)	269

- Brakes, (*continued*)
- friction, coefficient, variation with distance.....XX (02) 241
    - speed .....XX (02) 239
  - hysteresis, early type .....XX (02) 284
  - magnetic, early Edison .....XX (02) 284
    - traction, description .....XX (02) 271
      - mode of operation .....XX (02) 272
  - power, maintenance, cost .....XX (02) 231
    - operation, cost .....XX (02) 231
    - repairs, cost .....XX (02) 231
  - shoe friction, equation .....XX (02) 260
    - pressure, relation to weight on rails.....XX (02) 243
      - Ross type, advantages .....XX (02) 281
  - testing, methods .....XX (02) 224
  - tests, Westinghouse-Galton, account .....XX (02) 238
- Braking (see Retardation).
- compensating angles, for different size wheel
    - and wheel bases .....XX (02) 268
  - compensation for redistribution of forces in
    - trucks .....XX (02) 257
  - curves, plotting .....XIX (02) 934
  - distance, formula .....XX (02) 227
  - emergency, tests .....XX (02) 220
  - energy saving due to rapid.....XXIX (10) 1468
  - force, choice for different size wheels and wheel
    - bases .....XX (02) 268
      - distribution in trucks .....XX (02) 254
      - maximum allowable, equation .....XX (02) 266
    - high-speed, requirements .....XX (02) 246
    - inertia of rotating parts.....XIX (02) 166
    - ore handling machine .....XX (02) 297
    - pressure distribution on rails.....XX (02) 252
    - rate, maximum possible .....XX (02) 244
    - recuperative control, a.c. compared with d.c....XXVI (07) 716
      - methods .....XXVI (07) 714
      - value with three-phase system....XXIV (05) 486
    - testing, methods .....XX (02) 224
    - tests, Westinghouse-Galton, account .....XX (02) 238
    - time, formula .....XX (02) 229
- Brass electroplating process .....XIX (02) 282
- Breitfield's power-factor meter, mode of operation.....XVIII (01) 299
- Brilliancy, intrinsic, arc crater.....XX (02) 72
  - Argand burner .....XX (02) 72
  - carbon incandescent .....XX (02) 72
  - Nernst glower .....XX (02) 72
- Broad river, drainage area.....XXIV (05) 797
  - rainfall .....XXIV (05) 797
  - run-off .....XXIV (05) 797
- Brooklyn Rapid Transit Co. automatic telephone plant...XXIX (10) 96
- Brush arc machine (see Generators, arc).
- Brushes, carbon, current density, maximum.....XXIV (05) 700
  - spark pressures .....XXIV (05) 699
  - contact resistance, relation to velocity.....XXIV (05) 644
  - current density, determination .....XXIII (04) 451
    - maximum .....XXIV (05) 715
  - discharge, effect on insulation quality.....XXII (03) 356
  - graphite, current density, maximum.....XXIV (05) 700
  - spark pressures .....XXIV (05) 699

- Brushes, (*continued*)  
     life, single-phase railway repulsion motor.....XXVII (08) 40  
         series motors .....XXVII (08) 34  
     volt-ampere, density, various types.....XXIV (05) 705  
 Buffalo, load curve .....XVIII (01) 522  
 Buffalo-Niagara distribution system .....XVIII (01) 125  
     first pole line, construction.....XVIII (01) 512  
     second pole line, construction.....XVIII (01) 518  
     transmission line, record of service  
         interruption .....XXVIII (09) 1422  
         plant, net efficiency.....XVIII (01) 524  
 Bunsen photometer (see Photometer).  
     methods of use .....XX (02) 77  
 Buoy, selenium cell, description.....XXI (03) 387  
 Bureau of Standards, act establishing.....XXIV (05) 1000  
     administration .....XXIV (05) 1005  
     annual appropriations .....XXIV (05) 1006  
     Chemical section, duties .....XXIV (05) 1039  
     Electrical section, duties .....XXIV (05) 1031  
     Engineering instruments and ma-  
         terials section, duties .....XXIV (05) 1030  
     equipment, mechanical .....XXIV (05) 1007  
     Heat measurements section, duties.....XXIV (05) 1028  
     Louisiana Purchase Exposition.....XXIV (05) 1044  
     low-temperature building .....XXIV (05) 1016  
     Optics section, duties .....XXIV (05) 1029  
     personnel .....XXIV (05) 1002  
         grades .....XXIV (05) 1003  
     publications, list .....XXIV (05) 1042  
     site .....XXIV (05) 1001  
     tests, classification .....XXIV (05) 1041  
     transformer iron loss testing appa-  
         ratus .....XXVIII (09) 444  
     Weights and Measures section,  
         duties .....XXIV (05) 1024  
 Burgdorf-Thun three-phase railway, acceleration.....XVIII (01) 325  
     description .....XIX (02) 507  
     tests .....XIX (02) 520  
 Burnett luminometer, description .....XX (02) 75  
 Busbar compartments, typical construction.....XXIV (05) 34  
 Bushings, condenser type (also see Insulation).....XXVIII (09) 209  
     compared with oil-filled and  
         bulk types .....XXVIII (09) 253  
         construction .....XXVIII (09) 214  
         design, theory .....XXVIII (09) 211  
         method of design .....XXIII (04) 235  
         vs. bulk type, tests.....XXVIII (09) 217  
     high-tension corona (see Corona).  
         cost, actual, 44,000 volts.....XXV (06) 880  
         electric field .....XXVIII (09) 790  
         materials .....XXIII (04) 227  
         power loss at different e. m. f's...XXV (06) 879  
         troubles .....XXIII (04) 232  
     bulk type, compared with oil-filled and con-  
         denser types .....XXVIII (09) 253  
         vs. condenser type, tests .....XXVIII (09) 217  
     oil-filled type, compared with bulk and con-  
         denser types .....XXVIII (09) 253

Bushings, ( <i>continued</i> )		
wall, cost, actual, 44,000 volts.....	xxv (06)	880
early experience, Telluride Co. ....	xxv (06)	865
Cables, acid proof covering, for use in mines.....	xxvii (08)	1582
aluminium, elastic limit .....	xxiii (04)	514
armor, effect on inductance.....	xxviii (09)	739
reluctance, formula .....	xxviii (09)	738
armored, inductance .....	xxviii (09)	737
losses in armor .....	xxviii (09)	747
bridge, construction at Niagara Falls.....	xviii (01)	514
burnouts per mile, Int. Rapid Transit Co.....	xxvi (07)	1641
capacity, effect of duration of charge.....	xxix (10)	1612
temperature .....	xxix (10)	1613
clay conduits for protection.....	xxiii (04)	477
copper, conductivity, electric, effect of stranding.....	xxii (03)	703
elastic limit .....	xxiii (04)	513
impedance, effect of steel strands.....	xxiv (05)	399
corona effects .....	xxiii (04)	145
current-carrying capacity .....	xxvi (07)	559
in ducts.....	xxii (03) 440; xxiv (05)	409
deep-sea, connecting, method .....	xix (02)	634
differential duplex, wiring diagram.....	xix (02)	638
first American .....	xix (02)	630
laying, method .....	xix (02)	631
Signal Corps, repeater, wiring diagram.....	xix (02)	637
defective, automatic selection device.....	xxvi (07)	1619
distribution systems (see Distribution).		
double-conductor, iron-armored, impedance.....	xxviii (09)	745
resistance a.c.....	xxviii (09)	745
ducts, temperature tests .....	xviii (01)	509
electrolysis, asphaltum as protection.....	xxvii (08)	1533
bonding sheaths to negative loss,		
experience .....	xxvi (07)	301
effect of grounding sheaths.....	xxv (06)	205
protection by asphaltum .....	xxvii (08)	1522
insulation .....	xxvi (07)	300
insulating joints .....	xxv (06)	206
super position of direct		
current .....	xxvi (07)	223
of lead cover .....	xxvi (07)	299
energy losses, tests .....	xviii (01)	508
faults, location, compass method.....	xviii (01)	830
current reverser construction.....	xviii (01)	831
methods .....	xviii (01)	830
fireproofing in manholes .....	xxiii (04)	472
graded insulation, capacity formula.....	xxix (10)	1602
compared with homogeneous.....	xxix (10)	1596
design curves .....	xxix (10)	1560
effect of dielectric		
energy .....	xxix (10)	1605
formulas .....	xxix (10)	1577
history .....	xxix (10)	1556
multi-conductor .....	xxix (10)	1566
Russell's formula .....	xxix (10)	1557
ground indicator, connections .....	xxii (03)	423
heating in ducts .....	xxiv (05)	409
high-reactance, usefulness .....	xxiv (05)	417
specifications for 44,000-volt.....	xxv (06)	876

Cables, (*continued*)

high-tension, burnouts per mile, Interborough Rapid Transit Co. ....	xxvi	(07)	1641
construction practice .....	xxiii	(04)	593
critical frequency, calculation.....	xxvii	(08)	1256
wave length, calculation.....	xxvii	(08)	1256
early systems in U. S. ....	xxvii	(08)	1501
experience, 9,000-volt .....	xxii	(03)	433
11,000-volt .....	xxii	(03)	433
12,000-volt .....	xxii	(03)	433
23,000-volt .....	xxvii	(08)	1540
in England, 20,000-volt.....	xxvii	(08)	1531
faults, automatic indicator.....	xxii	(03)	423
heat generated, calculation.....	xxv	(06)	215
installation, practice .....	xxiii	(04)	593
insulation employed by various companies .....	xxvii	(08)	1504
life, 11,000-volt .....	xxv	(06)	209
maximum feasible e. m. f. ....	xxiii	(04)	803
xxvii (08) 1519, 1550			
oscillograph tests, Chicago Edison Co. ....	xxvii	(08)	1507
potential rises, 20,000-volt system.....	xxvii	(08)	508
magnitude .....	xxvii	(08)	1507
strain distribution with space and time .....	xix	(02)	274
puncture tests .....	xxv	(06)	200
record of faults, N. Y. Edison Co.....	xxii	(03)	422
requirements .....	xxii	(03)	417
rubber, experience .....	xviii	(01)	161
splicing .....	xxvii	(08)	1505
state of art .....	xxvii	(08)	1523
trouble record .....	xxvi	(07)	27
Cataract Power & Conduit Co.....	xxv	(06)	209
Chicago Edison Co.....	xxvii	(08)	1506
Int. Rapid Transit Co. ....	xxvii	(08)	1534
N. J. Public Service Corp. ....	xxvii	(08)	1543
N. Y. Edison Co.....	xxvii	(08)	1554
ice coat, thickness .....	xxvii	(08)	936
inductance formulas .....	xxviii	(09)	764
insulation (see Insulation).			
application of potential gradient to design .....	xxix	(10)	1615
breaking down, testing set.....	xxii	(03)	424
conductance effect of stress distribution .....	xxix	(10)	1564
dielectric conduction .....	xix	(02)	1067
stress, effect of load.....	xxix	(10)	1600
disadvantages of thick .....	xxv	(06)	208
effect of strains on dielectric strength.....	xxix	(10)	1618
temperature gradient in equalizing dielectric stress.....	xxix	(10)	1622
load, effect upon dielectric stress.....	xxix	(10)	1600
temperature and specific capacity.....	xxix	(10)	1600

Cables, insulation (*continued*)

methods of distributing potential		
stresses .....	XXIX (10)	1554
potential distribution .....	XXVIII (09)	210
resistance, effect of duration of charge .....	XXIX (10)	1610
temperature .....	XXIX (10)	1611
temperature chart for differ-		
ent makes .....	XIX (02)	688
formulas .....	XIX (02)	689
specific capacity, effect of load .....	XXIX (10)	1600
stress distribution, effect of tempera-		
ture .....	XXIX (10)	1566
temperature, effect of load .....	XXIX (10)	1600
iron, reactance formula .....	XXVI (07)	567
resistance to alternating current, formula .....	XXVI (07)	567
isolating in manholes .....	XXIII (04)	472
leaded, losses in sheath .....	XXVIII (09)	747
water-proof covering, formula .....	XXIII (04)	479
loop test, connections .....	XVIII (01)	901
multi-conductor, graded insulation .....	XXIX (10)	1566
paper, capacity, change with temperature .....	XXIV (05)	407
e. m. f.'s. for factory and installation tests .....	XXIV (05)	413
insulation resistance, change with tem-		
perature .....	XXIV (05)	406
requirements .....	XXII (03)	417
Philippine, electrical properties .....	XIX (02)	639
laying .....	XIX (02)	629
mechanical properties .....	XIX (02)	639
power, fault location, formula .....	XVIII (01)	901
loop test, connections .....	XVIII (01)	901
protection in power stations .....	XXIII (04)	475
reactance table for different sizes and spacings .....	XXIV (05)	401
rubber, capacity change with temperature .....	XXIV (05)	404
relation to durability .....	XXV (06)	209
characteristics .....	XXV (06)	195
durability relation to electrical properties .....	XXV (06)	209
insulation resistance as index of quality		
of insulation .....	XXV (06)	204
change with tem-		
perature .....	XXIV (05)	404
relation to dura-		
bility .....	XXV (06)	209
tests .....	XXV (06)	200
puncture e. m. f., relation to durability .....	XXV (06)	209
tests .....	XXV (06)	200
choice of potential .....	XXV (06)	203
specifications for 30 per cent. compound .....	XXV (06)	211
requirements .....	XXII (03)	417
Signal Corps, armor wire, tensile strength .....	XIX (02)	694
specifications .....	XIX (02)	686
single-conductor, armored, effect of cross bond-		
ing armor and		
sheath .....	XXVIII (09)	755
impedance, calcula-		
tion .....	XXVIII (09)	759
capacity formula .....	XXVI (07)	560
constants, effect of grounded		
sheath .....	XXVI (07)	560

Cables, single-conductor, constants, effect of ( <i>continued</i> )		
iron armor..xxvi	(07)	565
ungrounded sheath ..xxvi	(07)	564
copper-armored, currents in sheath and armor	...xxviii (09)	752
e. m. f. in sheath and armor	...xxviii (09)	752
impedance..xxviii	(09)	744
resistance a. c. ....xxviii	(09)	744
grounded sheath, effect on constants	.....xxvi (07)	560
inductance formula	.....xxvi (07)	560
iron-armored, currents in sheath and armor..xxviii	(09)	748
effect on constants	.....xxvi (07)	565
e. m. f. in sheath and armor..xxviii	(09)	748
impedance..xxviii	(09)	742, 751
reactance	.....xxviii (09)	742
resistance a. c. ...xxviii	(09)	742
sheath, effect on constants.....xxvi	(07)	564
steel-tape armored, currents in sheath and armor	...xxviii (09)	755
e. m. f. in sheath and armor	...xxviii (09)	755
impedance..xxviii	(09)	754
strand formulas	.....xxiv (05)	400
stray currents, detection	.....xxiii (04)	476
submarine, Philippine, account of laying.....xix	(02)	629
electrical properties.....xix	(02)	639
mechanical properties	.....xix (02)	639
stations, names and distances	.....xix (02)	639
surges, investigation	.....xxviii (09)	805
system N. J. Public Service Corp., description.....xxvii	(08)	1542
telegraph, fault distance formula.....xxvii	(08)	1731
submarine, critical wave, calculation..xxvii	(08)	1258
transposition location, formula.....xxvii	(08)	1724
trouble record	.....xxvi (07)	27
telephone, attenuation constant formula.....xxviii	(09)	1084
capacity, actual	.....xxviii (09)	1088
effects of drying	.....xxviii (09)	1089
choice of type	.....xxv (06)	87
construction standard	.....xxviii (09)	1081
cotton, beeswax insulation, experience..xxvi	(07)	597
dry-core insulation, experience..xxvi	(07)	597
damping constant, actual.....xxviii	(09)	1085
dielectric, choice	.....xxviii (09)	1083
strength	.....xxviii (09)	1087
fault distance formula.....xxvii	(08)	1724
inductance, actual	.....xxviii (09)	1085



- Cables, telephone, (*continued*)
- insulation resistance, actual.....xxviii (09) 1086
  - maintenance, effect of common battery
    - working .....xxi (03) 68
  - mutual capacity, actual.....xxviii (09) 1085
  - paper, effect of drying upon electrical
    - properties .....xxviii (09) 1087
    - disadvantages .....xxvi (07) 603
  - overhead, critical wave length, calcu-
    - lation .....xxvii (08) 1258
  - requirements .....xxviii (09) 1079
  - sheathing, requirements .....xxviii (09) 1090
  - specifications for subscribers lines in
    - multi-office systems .....xxvii (08) 549
    - split pairs, location, formulas.....xxvii (08) 1731
    - terminal, standard construction.....xxvi (07) 578
    - transpositions, location formula.....xxvii (08) 1731
    - trouble record .....xxvi (07) 27
  - temperature tests .....xxviii (01) 510
  - testing, choice of e. m. f. ....xxix (10) 1596
    - set for breaking down insulation.....xxii (03) 424
  - thermal drop between core and sheath, tests.....xxviii (01) 510
  - three-conductor, losses, copper, a. c. ....xxviii (09) 766
    - eddy-current .....xxviii (09) 766
  - troubles record, Chicago Edison Co. ....xxvii (08) 1506
    - Int. Rapid Transit Co.....xxvii (08) 1534
    - N. J. Public Service Corp.....xxvii (08) 1543
    - N. Y. Edison Co. ....xxvi (07) 1615
    - xxvii (08) 1554
  - tying method used by Niagara, Lockport &
    - Ontario Power Co. ....xxvi (07) 1298
  - underground, Army specifications .....xix (02) 681
    - faults classification .....xxvi (07) 25
    - high-tension, Chicago Edison Co.....xxvii (08) 1500
      - early systems in
        - U. S. ....xxvii (08) 1501
        - splicing.....xxvii (08) 1505
      - solid system, advantages.....xxvii (08) 1529
      - static disturbance due to charging..xix (02) 233
      - trouble records .....xxvi (07) 27
    - war, first laid by U. S. government.....xix (02) 710
    - watt consumption permissible in conduits.....xxiii (04) 476
    - wind pressures, tests .....xxvii (08) 935

Calcium carbide, discovery .....xix (02) 297
 
    - electrolytic production .....xix (02) 290

Calculograph, invention and evolution.....xxv (06) 524

California Gas & Electric Corp., insulator pins, dimen-
 
    - sions .....xxi (03) 268
    - switching arrangement
      - plan .....xxvi (07) 1568
    - southern, estimated water power.....xxvii (08) 380

Calorimeter, low-pressure, separating-throttling, design.....xxix (10) 222

Camphor, electric reduction process.....xix (02) 355

Canal boats (see Boats).

    - haulage, cost with mules, steam propellers, and
      - electric motors .....xxvii (08) 317
      - efficiency electric tractors .....xxvii (08) 287
      - mining locomotives .....xxvii (08) 287

- Canal haulage, (*continued*)
- energy consumption with different types
    - of towing machines.....XXVII (08) 309
  - limitations to length of tow.....XXVII (08) 294
  - losses with different types of electric tow-
    - ing machines .....XXVII (08) 289
  - maximum pull with mules.....XXVII (08) 294
  - power requirements .....XXVII (08) 285
  - ratio of boats to towing machines.....XXVII (08) 302
  - relation between towage and length of
    - tows .....XXVII (08) 301
  - relative efficiency of a. c. and d. c. motors.....XXVII (08) 305
  - speed limitations .....XXVII (08) 294
    - with mules .....XXVII (08) 294
  - tests, Lehigh Canal .....XXVII (08) 277
  - time required for locking.....XXVII (08) 297
  - relation
    - tow .....XXVII (08) 301
- Candle-power (see Luminous intensity).
- mean horizontal, measurement with the
    - Matthews photometer .....XX (02) 65
    - spherical, determination .....XX (02) 60
    - equation .....XX (02) 61
    - measurement with the
      - Matthews photometer...XX (02) 68
  - spherical reduction factor, measurement
    - with Matthews photometer.....XX (02) 69
  - vertical distribution, measurement with
    - Matthews photometer .....XX (02) 67
- Capacity, current-carrying (see Current).
- electric, concentric cylinders, formula...XXVIII (09) 211, 252
  - cylinder and plate formula.....XXVIII (09) 770
  - image conductor, explanation.....XXVIII (09) 1230
  - parallel conductors, formula...XXIII (04) 111; XXVIII (09) 1205, 1246
    - derivation...XXVI (07) 556
  - plate condenser, formula .....XXVI (07) 1113
  - single-conductor cables, formula.....XXVI (07) 560
  - transmission line, calculation.....XXIII (04) 666
    - formula .....XXIII (04) 669
    - XXVI (07) 163
    - representation ....XXVII (08) 1406
  - susceptance for parallel wires, table.....XXVII (08) 1422
- Cape Fear river, rainfall.....XXIV (05) 795
- run-off .....XXIV (05) 795
- Cars, electric, inertia of rotating parts.....XIX (02) 166
- energy consumption, effect of air brakes.....XX (02) 280
  - motor, direct-current weight compared with three-
    - phase .....XXIV (05) 512
    - three-phase weight compared with d. c....XXIV (05) 512
  - railway, illumination required .....XXI (03) 175
  - street, energy consumption, tests.....XXIV (05) 66
    - four-motor vs. two-motor equipments...XXIV (05) 76, 79
    - operating cost per seat mile.....XXIV (05) 78
    - platform labor, costs .....XXIV (05) 71
  - subway weights, seated and standing loads.....XXIII (04) 694
  - suspended monorail, dimensions .....XVIII (01) 58
    - weight .....XVIII (01) 61

Cars, ( <i>continued</i> )			
trailer, tilting action tests.....	XXIX	(10)	1457
wheels, radius of gyration.....	XIX	(02)	166
Carbides, properties .....	XIX	(02)	297
structural formula .....	XIX	(02)	298
Carbon boiling point .....	XXV	(06)	791
conductivity, electric, at high temperatures.....	XXIX	(10)	506
heat, at high temperatures.....	XXIX	(10)	536
tests.....	XXIX	(10)	506
dioxide recorder, description .....	XXVI	(07)	1777
sources of error .....	XXVI	(07)	1784
filaments (see Filaments).			
lamps (see Lamps).			
regulator, mode of operation.....	XXVII	(08)	996
resistivity, electric, at high temperatures, tests.....	XXIX	(10)	506
heat, at high temperatures.....	XXIX	(10)	536
tests.....	XXIX	(10)	506
resistivity-temperature characteristics .....	XXIV	(05)	841
Carborundum, electrolytic production .....	XIX	(02)	290
Casino Technical Night School, scope of work.....	XXVIII	(09)	1099
Cataract Power & Conduit Co., record of burnouts in			
cable system.....	XXV	(06)	209
system description.....	XVIII	(01)	840
Catawba river, drainage area.....	XXIV	(05)	796
rainfall .....	XXIV	(05)	796
run-off .....	XXIV	(05)	796
Catenary construction, auxiliary trolley, N. Y. N. H. &			
H. R. R. ....	XXVII	(08)	1625
bracket-arm .....	XXIV	(05)	124
bridge .....	XXIV	(05)	136
contact wire wear.....	XXVII	(08)	1697
cross-span .....	XXIV	(05)	131
deflectors, types .....	XXIX	(10)	1003
double .....	XXIV	(05)	138
effect of locomotive blast on steel			
wire .....	XXVII	(08)	1705
first in U. S. ....	XXIX	(10)	976
world .....	XXIX	(10)	1012
frogs, types .....	XXIX	(10)	1003
hangers, types .....	XXIX	(10)	993, 1021
insulators (see Insulators).			
types .....	XXIX	(10)	1002
light bridge, cost.....	XXIX	(10)	986
lightning protection (also see			
Lightning) .....	XXIX	(10)	1005
London, Brighton & South Coast			
Ry. ....	XXVII	(08)	1700
offsets in curves .....	XXIX	(10)	981
Pennsylvania R. R., tests.....	XXIX	(10)	1014
poles required .....	XXIX	(10)	978
spacing .....	XXIX	(10)	981
at curves .....	XXIX	(10)	981
section break, N. Y. N. H. &			
H. R. R. ....	XXVII	(08)	1638
spacing on curves .....	XXIX	(10)	981
splices .....	XXIX	(10)	1005
standard location of contact wire.....	XXVI	(07)	135

- Catenary, construction, (*continued*)
- steel trolley, copper messenger....XXIX (10) 1020
  - tension in copper.....XXIX (10) 987, 1019
    - equalization .....XXIX (10) 990, 992
    - phono-electric wire .....XXIX (10) 988
  - types .....XXIX (10) 977
  - typical .....XXIX (10) 977
  - wire splices .....XXIV (05) 123
  - spans, effect of temperature on sag.....XXIV (05) 1005
  - messenger tension .....XXIV (05) 128
- Cathode tube, high-tension, construction.....XXII (03) 546
- price .....XXII (03) 548
  - wave tracer (see Wave meter).
  - construction .....XXII (03) 540
- Cells, aluminium, care .....XXVIII (09) 848
- cooling .....XXVIII (09) 848
  - construction .....XXVIII (09) 845
  - discharge rate .....XXVIII (09) 846
  - division of e. m. f. ....XXVIII (09) 847
  - energy losses .....XXVIII (09) 846
  - film, destruction and reformation...XXVIII (09) 848
  - shunting reactor, action .....XXVIII (09) 809
  - surge protector, demonstration test...XXVIII (09) 840
  - temperature rise .....XXVIII (09) 846
- Clark, e. m. f. determination by Barnes.....XXII (03) 522
- Guthe .....XXII (03) 522
  - Moorby .....XXII (03) 522
  - Reynolds .....XXII (03) 522
  - experimentally determined value....XXII (03) 521
  - legal value .....XXII (03) 521
  - ratio to Weston .....XXII (03) 522
- electrolytic, current measurement without electrodes...XIX (02) 314
- without electrodes .....XIX (02) 312
- Weston, advantages as standard.....XXII (03) 523
- e. m. f. equation .....XXII (03) 522
  - ratio to Clark .....XXII (03) 522
- Cement, pyro-conductivity .....XXVII (08) 738
- resistivity, effect of age.....XXVII (08) 733
    - moisture .....XXVII (08) 736
    - temperature .....XXVII (08) 737
- Central station (see Power plants).
- advantages of large size.....XXI (03) 414
  - apparatus losses .....XXVI (07) 677
  - choice of ratio of fixed charges to operating charges .....XXIV (05) 45
  - cost of distribution .....XXIX (10) 132
    - energy production compared with isolated plants .....XXIX (10) 131
  - design, ratio first cost to operation cost...XXIV (05) 45
  - use of cement .....XXIV (05) 55
  - disadvantages of large size.....XXI (03) 414
  - distribution system (see Distribution).
  - choice .....XXI (03) 408
  - diversity factor, analytical study.....XXIX (10) 375
  - Edison, date of first.....XXI (03) 173
  - financial statistics for U. S. ....XXIV (05) 44
  - gas-electric, advantages .....XXII (03) 773

- Central station (*continued*)
- investment, effect of diversity-factor.....xxix (10) 383
  - layout, principles .....xviii (01) 418
  - location .....xxiv (05) 29
  - meter cost, effect of diversity factor.....xxix (10) 383
  - operation with load dispatcher.....xxi (03) 439
  - parallel vs. independent operation of units.....xxi (03) 425
  - plant, distribution of investment.....xxi (03) 437
    - feeder losses .....xxvi (07) 678
    - mains, losses .....xxvi (07) 678
    - overall efficiency .....xxix (10) 341
    - reliability, methods of maintaining.....xxix (10) 357
  - power plant economics.....xxv (06) 1
  - records, importance of keeping.....xxix (10) 355
  - reliability, method of maintaining.....xxi (03) 418
  - reserve apparatus .....xxiv (05) 278
    - classification .....xxiv (05) 261
  - safety devices .....xxi (03) 418
  - sectional layout .....xxi (03) 435
  - service interruptions, classification.....xxii (03) 755
  - space distribution among various appa-  
ratus .....xxi (03) 437
  - system, Berlin, Germany.....xviii (01) 826
    - loss, distribution .....xxvi (07) 665
    - Milan, Italy .....xviii (01) 827
  - transmission losses .....xxvi (07) 678
  - wiring (see Wiring).
- Centrifugal pumps (see Pumps).
- Charges, bound, transmission lines, theory.....xxvii (08) 421
- electrons, magnitude .....xxvi (07) 940
  - electric, definition .....xxvi (07) 402
    - transmission line, causes.....xxvi (07) 402
- Charlotte Electric Ry. Co. gas engine plant, description.....xxix (10) 428
- Chattahoochee river, run-off .....xxiv (05) 799
- Chicago Edison Co. distribution system, operation.....xxi (03) 427
- Fisk Street Station, wiring diagram.....xxiii (04) 240
  - Harrison Street Station, wiring  
diagram .....xxiii (04) 239
  - map of distribution system.....xviii (01) 824
  - substation connections .....xxi (03) 429
  - transmission system, layout.....xxi (03) 432
- local A. I. E. E. organization, beginning.....xxv (06) 656
- river, effect of reversing upon Niagara Falls.....xxiv (05) 834
- telephone service, quality tests.....xxix (10) 102
- Choke coils (see Coils).
- Churches, lighting, general remarks.....xxv (06) 643
- illumination intensity .....xxv (06) 644
  - specifications .....xxv (06) 646
- Circuits, a. c., calculation, clock diagram.....xxi (03) 591
- necessity of choosing signs.....xxi (03) 593
  - topographical vs. vector method.....xxi (03) 594
  - vector vs. topographical method.....xxi (03) 594
- capacity susceptance factors, table.....xxvii (08) 1422
- complex, free oscillations, equation.....xxvii (08) 1291
- cross-section factor, table .....xxvii (08) 1420
- distribution, disturbances of telephone and  
telegraph lines .....xxviii (09) 1190
- effect of superposed d. c. ....xxviii (09) 729

Circuits, a. c., (*continued*)

e. m. f. rise due to interruption of given		
current, formula .....	XXVI (07)	178
destructive, source .....	XVIII (01)	404
general equations at transition points.....	XXVII (08)	1282
inductive disturbance, calculation.....	XXVIII (09)	1206
multiple, admittance formula.....	XXVII (08)	1397
reactance factor .....	XXVII (08)	1400
phase unbalance (see Phase unbalance).		
polyphase, balancing effect of induction		
motor .....	XXVIII (09)	1270
energy measurement .....	XVIII (01)	283
unbalanced, effect on open		
delta .....	XXVIII (09)	1258
unbalanced, effect on T-con-		
nected transformers .....	XXVIII (09)	1262
unbalanced, effect on two-phase		
three - wire transformer		
break .....	XXVIII (09)	1256
protection from surges .....	XXVIII (09)	1163
railway, inductance .....	XXVIII (09)	1238
reactance factors, table .....	XXVII (08)	1420
reflection at transition point.....	XXVII (08)	1299
refraction at transition point.....	XXVII (08)	1299
regulation, storage battery and split-pole		
converter .....	XXVIII (09)	851
storage battery, uses.....	XXVII (08)	987
resistance factors, table.....	XXVII (08)	1420
resonant frequency, capacity and induct-		
ance in series .....	XXVI (07)	1198
selective breaking system.....	XXVII (08)	1680
series, impedance formula.....	XXVII (08)	1397
reactance factor .....	XXVII (08)	1400
single-phase, loss equation.....	XVIII (01)	904
three-phase, loss equation.....	XVIII (01)	905
two-phase, loss equation.....	XVIII (01)	905
arc, Brush, use of transformer.....	XXVIII (09)	33
maximum e. m. f. variation.....	XXIV (05)	376
multiple, instability .....	XXVIII (09)	20
composite telegraph-telephone .....	XXIX (10)	1322
dielectric, effect of joint.....	XXIX (10)	1582
d. c., loss equation .....	XVIII (01)	904
electric equivalent of induction motor.....	XXVII (08)	1413
transformer .....	XXVII (08)	1409
general equation, Steinmetz, derivation.....	XXVII (08)	1234
stability definition .....	XXVIII (09)	I
lighting, stability .....	XXVIII (09)	I
telegraph, disturbances from a. c. lines.....	XXVIII (09)	1169
defects in neutralizing		
transformers .....	XXVII (08)	1684
duplex .....	XXVIII (09)	1171
inductive disturbances, Applegate		
neutralizing device .....	XXIX (10)	1326
inductive disturbances, Blakeney-		
Chetwood neutralizing device....	XXIX (10)	1327
inductive disturbances, neutralizing		
transformer .....	XXIX (10)	1327

Circuits, telegraph, (*continued*)

inductive disturbances, Wilson neu-		
tralizing device .....	xxix	(10) 1325
metallic circuits, classification.....	xxviii	(09) 1176
methods of mapping.....	xxix	(10) 1331
phantoflex, description .....	xxix	(10) 1321
single-wire .....	xxviii	(09) 1171
symbols, Atchison & Topeka.....	xxix	(10) 1353
Baltimore & Ohio.....	xxix	(10) 1347
Canadian Pacific .....	xxix	(10) 1347
Northern Pacific .....	xxix	(10) 1347
testing instruments .....	xxix	(10) 1333
typical .....	xxviii	(09) 1171
telegraph-telephone, composite .....	xxix	(10) 1322
telephone, automatic trunking .....	xxix	(10) 1363
two-wire system intercon-		
nected with three-wire.....	xxix	(10) 1376
cable, efficiency compared with open-		
wire .....	xxviii	(09) 1079
disturbances from a. c. lines.....	xxviii	(09) 1169
insulating transformers, objections.....	xxviii	(09) 1236
open-wire efficiency compared with		
cable .....	xxviii	(09) 1079
parallel high tension, protection.....	xxviii	(09) 1237
paralleling power lines, design.....	xxi	(03) 285
operation.....	xxix	(10) 710
protection from parallel high tension		
lines .....	xxviii	(09) 1237
telephone-telegraph, composite .....	xxix	(10) 1322
transmission, electrical properties.....	xix	(02) 218
static discharge, laws.....	xix	(02) 215
two-phase from single-phase generators.....	xix	(02) 856
unbalanced, commercial aspects.....	xxviii	(09) 579
regulating effect of induction and		
synchronous motors .....	xxviii	(09) 585
voltage unbalance (see Voltage).		
Circuit-breaker, mercury type, advantages.....	xxii	(03) 85
Niagara plant, description .....	xviii	(01) 495
performance on grounded high-tension		
single-phase system .....	xxvii	(08) 1621
reverse power, description.....	xviii	(01) 134
first use .....	xviii	(01) 502
selective system, New Haven road.....	xxvii	(08) 1680
shunted fuse type, description.....	xviii	(01) 131
top vs. bottom-connected, in high-tension		
service .....	xxvi	(07) 1341
Claude's power-factor meter, mode of operation.....	xviii	(01) 294
Clark cell (see Cell).		
Clock diagram vs. polar co-ordinates.....	xxi	(03) 591
Clothes drying room, electric, heating capacity, deter-		
mination .....	xxvii	(08) 658
Coal, analysis, methods .....	xxviii	(09) 58
bituminous, average moisture .....	xxii	(03) 504
extent of supply in U. S. ....	xxvii	(08) 379
consumption, railway electric .....	xix	(02) 850
steam .....	xix	(02) 850

Coal, consumption, (*continued*)

steam locomotive suburban service,		
actual .....	XXIX (02)	849
cutters, description .....	XXVII (08)	1573
gases occluded .....	XXIX (10)	463
handling, automatic, cost .....	XXI (03)	458
hand, cost .....	XXI (03)	458
heat value criteria .....	XXVIII (09)	53
hoist, power requirements .....	XX (02)	139
mines (see Mines).		
Pocahontas, analysis .....	XXIX (10)	455
punchers, description .....	XXVII (08)	1573
purchase, premiums and penalties based on		
analysis .....	XXVIII (09)	56
sampling, methods .....	XXVIII (09)	54
stove efficiency .....	XXVII (08)	1605
thermal value, determination .....	XXVIII (09)	60
total production of U. S. ....	XXVII (08)	379
value as fertilizer .....	XXVIII (09)	1388
Coal-to-Rock ratio, steam mine hoists, tests.....	XXIX (10)	332
Coast defenses, definitions .....	XIX (02)	665
load characteristics .....	XIX (02)	673
power plant design .....	XIX (02)	667
Coasting clock, description .....	XXIX (10)	1461
effect on per cent. coasting in Manhattan		
Elevated lines, actual .....	XXIX (10)	1484
curves, plotting .....	XIX (02)	934
effect of coasting clock on Manhattan Elevated		
Ry. lines .....	XXIX (10)	1484
tests, Manhattan Elevated Ry. lines.....	XXIX (10)	1482
Coefficients, thermal, various materials (see Name of		
material).		
Coils, astatic, mutual inductance, construction.....	XXIX (10)	1526
choke, advantages in protection of apparatus.....	XXVI (07)	1170
XXVII (08) 696		
danger in using .....	XXVI (07)	1194
design for lightning protection.....	XXVI (07)	1207
differential, for preventing power reversal.....	XXII (03)	307
disadvantages in protection of apparatus.....	XXVI (07)	1171
effect of capacity .....	XXV (06)	910
lightning .....	XXV (06)	906
effectiveness in lightning protection.....	XXV (06)	410
XXVII (08) 431		
experience in lightning protection.....	XXV (06)	924
XXVII (08) 763		
function in lightning protection.....	XXIII (04)	566
in converter leads, function.....	XXIV (05)	1110
oil, objections .....	XXVI (07)	1201
transformer case .....	XXVI (07)	1172
inductance formula .....	XXV (06)	888
location for lightning protection.....	XXV (06)	902
protecting station apparatus.....	XXVI (07)	1197
performance, mechanical analogy.....	XXV (06)	884
under sudden stress, effect		
of capacity .....	XXV (06)	910
prevention of sparking in a. c. series motors,		
tests .....	XXIX (10)	29



- Coils, choke, (*continued*)
- protection afforded transformers.....xxv (06) 914
    - under sudden stress .....xxv (06) 909
    - oil switches .....xxix (10) 1075
  - protective power, tests.....xix (02) 259; xxvi (07) 1203
  - relation between inductance and surge re-
    - flecting power .....xxv (06) 887
    - test of protective value.....xxvi (07) 1194
    - use in lightning protection, experience.....xxiii (04) 564
    - value in protecting apparatus.....xxvi (07) 1191, 1192
  - field alternator, mechanical construction.....xxiii (04) 279
  - Coherer, inventor .....xix (02) 573
  - Colloidal solutions, characteristics .....xix (02) 345
    - compared with ordinary .....xix (02) 345
    - definition .....xix (02) 344
    - explanation .....xix (02) 344
    - method of precipitating .....xix (02) 347
    - precipitating power, various electro-lytes .....xix (02) 349
  - Colloids, definition .....xix (02) 357, 361
    - properties, mechanical explanation.....xix (02) 362
    - theory, electric .....xix (02) 368, 371
    - mechanical .....xix (02) 362
  - Columbia University, method of teaching engineering...xxvi (07) 1457
  - Columns, strength, formula .....xxvi (07) 1227
  - Commissions, public utility, choice of personnel.....xxvii (08) 350
    - 354, 357, 363, 366
    - purpose .....xxvii (08) 340
  - Commonwealth Edison Co., high potential underground
    - system, description .....xxvii (08) 1500
  - Commutating poles, action in d. c. generators.....xxix (10) 1628
    - synchronous converters...xxix (10) 1634
      - advantages .....xxv (06) 338
      - early experience .....xxv (06) 340
      - effect on limiting of synchronous
        - converters .....xxix (10) 1642
        - short-circuit current of
          - generators and con-verters .....xxix (10) 1641
      - excitation relation to speed.....xxv (06) 334
      - saturation curve .....xxv (06) 332
      - synchronous converters .....xxix (10) 1625
        - advantages and disad-vantages ..xxix (10) 1652
      - use with dampers in synchronous
        - converters .....xxix (10) 1674
      - windings, action of inductive shunt..xxix (10) 1658
        - use of shunts .....xxix (10) 1638
  - Commutation, action of pole-face windings.....xxvii (08) 152
    - commutating poles (see Commutating poles).
    - conditions that affect, classification.....xxiv (05) 701
    - contact resistance, relation to velocity.....xxiv (05) 644
    - converters, split-pole .....xxvii (08) 1044
      - synchronous .....xxix (10) 1630
        - action of commu-tating poles.....xxix (10) 1634
        - general discussion.xxix (10) 1625
        - self-starting .....xxix (10) 1676

Commutation, (*continued*)

current equation .....	XXIV (05)	613
d. c. machines, conditions favorable.....	XIX (02)	1134
series, commutating pole, flashing and creeping distances .....	XXVI (07)	1418
effect of ratio of slot width to slot depth.....	XXIII (04)	369
e. m. f. oscillograms .....	XXIII (04)	382
energy density on commutator, determina- tion .....	XXIV (05)	624
fractional, theory .....	XXIX (10)	1655
function of air blast in Thomson-Houston arc machine .....	XXVIII (09)	12
generators, d. c. ....	XXIX (10)	1627
action of commutating poles .....	XXIX (10)	1628
motors, a. c. ....	XXVII (08)	36
Heyland, ideal conditions.....	XXI (03)	526
repulsion, conditions for perfect .....	XXVII (08)	4
principles .....	XXVIII (09)	497
series .....	XXVII (08)	137
methods of improving.....	XXVII (08)	141
sparking, balanced choke coils, tests.....	XXIX (10)	29
sparking prevention.....	XXIX (10)	28
troubles .....	XXIX (10)	27
use of preventive leads .....	XXVII (08)	142
d. c., methods of improving.....	XXV (06)	330
railway, troubles .....	XXVI (07)	1408
series commutating pole, potential between segments .....	XXVI (07)	1414
flashing and creep- ing distances.....	XXVI (07)	1418
potential between segments .....	XXVI (07)	1414
shunt, weakened field.....	XX (02)	172
theory .....	XXVI (07)	1409
railway, fundamental features.....	XXIII (04)	379
preventive leads, life of brushes.....	XXVII (08)	34
reactance e. m. f., double-commutator.....	XXIV (05)	694
equation .....	XXIV (05)	691
rectifying commutator .....	XXV (06)	64
reversal e. m. f. calculation .....	XXIV (05)	630
self-inductance commutated coil, calculation.....	XXIII (04)	343
double-commutator .....	XXIV (05)	694
e. m. f. commutated coil, formula .....	XXIII (04)	369
formula .....	XXIII (04)	366
equation .....	XXIV (05)	691
sparking constant, formula.....	XXIII (04)	377
value for different types of series and shunt machines .....	XXIII (04)	378
theory with commutating poles.....	XXV (06)	333
temperature equation .....	XXIV (05)	627

Commutator, temperature ( <i>continued</i> )		
variation at commutator surface .....	XXIV (05)	612
troubles, classification .....	XXIV (05)	701
Commutator, blackening, cause .....	XXIV (05)	643
energy density allowable .....	XXIV (05)	625
induction motors (see Motors, repulsion).		
motors (see Motors).		
rectifying, Alexanderson, oscillograms of		
current .....	XXV (06)	65
commutation .....	XXV (06)	64
temperature equation .....	XXIV (05)	627
variation at surface .....	XXIV (05)	612
velocity, relation to brush contact resistance .....	XXIV (05)	644
Comparator, accuracy .....	XXIV (05)	755
adjustment under various conditions .....	XXIV (05)	752
circuit diagram .....	XXIV (05)	745
description .....	XXIV (05)	742
Compass, use in locating cable faults .....	XVIII (01)	831
Compensator a. c. line drop .....	XXVII (08)	272
Concentric method of teaching .....	XXVI (07)	1441
Concrete foundations, electric resistance .....	XXVI (07)	1216
mixing in freezing weather .....	XXIV (05)	56
resistivity, effect of age .....	XXVII (08)	733
water friction coefficient .....	XXV (06)	154
work, cost with electric shovel .....	XXIX (10)	370
Condensers, electric capacity formula, concentric cylinders .....	XXVIII (09)	211, 252
cylindrical, graded capacity formula .....	XXIX (10)	1602
high-tension, construction .....	XXVI (07)	1112
limitations for high-tension e. m. f.		
measurements .....	XXIV (05)	424
plate, capacity formula .....	XXVI (07)	1113
synchronous, inventor .....	XXIII (04)	505
electrolytic, aluminium (see Cell).		
mode of operation .....	XIX (02)	293
steam, as calorimeter .....	XXIX (10)	1701
barometric, cost .....	XXIV (05)	46
jet, cost .....	XXIV (05)	49
surface, cost .....	XXIV (05)	46, 49
Conduction, electric, arcs, effect of electric waves .....	XXV (06)	740
theory .....	XXV (06)	802
electronic theory .....	XXVI (07)	952
flames .....	XXV (06)	738
salt vapors .....	XXV (06)	737
vacuum .....	XXV (06)	601
effect of corpuscles .....	XXV (06)	767
electric waves .....	XXV (06)	741
temperature .....	XXV (06)	744
vapor, electronic theory .....	XXV (06)	609
physical nature .....	XXV (06)	608
electrolytic, in oil switches .....	XXIX (10)	1097
without electrodes .....	XIX (02)	312, 361, 372
thermal, electronic theory .....	XXVI (07)	954
Conductivity, electric, copper, properties .....	XXII (03)	695
relation to selective radiation .....	XXVI (07)	966
various materials (see Name of material).		

- Conductivity, (*continued*)  
     thermal, various materials (see Name of material).
- Conductors, aluminium, Niagara Falls Power Co. lines...xxviii (01) 521  
     cables (see Cables).  
     image, explanation .....xxviii (09) 1230  
     line, stranded vs. solid.....xxviii (01) 421  
     liquid, production of current without electrodes .....xix (02) 312  
     stranded, formulas for relations between dimensions .....xxiv (05) 400  
     wires (see Wires).
- Conduits, clay, protection of cables.....xxiii (04) 477  
     construction, Niagara Falls Power Co.....xxviii (01) 496  
     ducts, temperature tests .....xxviii (01) 509  
     system, manhole spacing .....xxviii (01) 830
- Connolly & McTighe, automatic telephone system.....xxi (03) 31
- Conservation charges based on production.....xxvii (08) 488  
     coal saved by use of Niagara water power .....xxviii (09) 165  
     committee, resolution to appoint.....xxiv (05) 804  
     energy output of Niagara Falls Power Co. plants .....xxviii (09) 165  
     part played by electricity.....xxviii (09) 163  
     supply .....xxvii (08) 377  
     forest reserves, object .....xxviii (09) 180  
     local vs. national policy.....xxvii (08) 494, 497  
     relation to water power development.....xxviii (09) 1362  
     water-power discussion .....xxix (10) 1037  
     policy Forest Service...xxvii (08) 486, 490
- Contact e. m. f., electronic theory.....xxvi (07) 956  
     nature .....xix (02) 343
- Control, benchmark, advantages .....xix (02) 806  
     disadvantages .....xix (02) 775, 804  
     e. m. f., adjustable reluctance method.....xix (02) 1131  
     in disruptive tests .....xxv (06) 387  
     feeder induction regulator.....xxvii (08) 260  
     induction regulator with Tirrill regulator control .....xxvii (08) 266  
     multi-tap transformer .....xxvii (08) 258  
     reactance method .....xxvii (08) 257  
     resistance method .....xxvii (08) 256  
     Tirrill induction regulator combination .....xxvii (08) 266  
     generator, Thomson automatic regulator .....xxvii (08) 265  
     energy, danger of concentration.....xxviii (01) 418  
     field strength, adjustable reluctance method.....xix (02) 1131  
     frequency disruptive tests .....xxv (06) 387  
     load, dispatcher system .....xxix (10) 708  
     dispatching system .....xxviii (09) 1468  
     mercury vapor converter current.....xxv (06) 624  
     mine hoist motors .....xxii (03) 558  
     motor, adjustable reluctance method.....xix (02) 1131  
     automatic, general .....xxviii (09) 913  
     systems .....xxviii (09) 913  
     boost and retard system, performance....xx (02) 175  
     classification .....xx (02) 127

Control, motor, (*continued*)

counter e. m. f. system .....	xxviii (09)	916
current-limit system .....	xxviii (09)	918
equalizer, teaser, boost and retard system, performance .....	xx (02)	175
field current method, limitations.....	xx (02)	121
induction, automatic .....	xxviii (09)	934, 945
differential concatenation.....	xix (02)	528
external concatenation.....	xxviii (09)	604
internal concatenation.....	xxviii (09)	603
611, 613		
regenerative, tests .....	xxviii (09)	1313
rolling mills .....	xxviii (09)	134
single-phase .....	xx (02)	21
three-phase locomotive.....	xxviii (09)	1339
variable number of poles.....	xxviii (09)	602
various methods .....	xxviii (09)	601, 610
machine tools, choice .....	xxix (10)	632
multivoltage, advantages .....	xx (02)	119
pilot motor system.....	xxviii (09)	917
railway, three-phase liquid rheostat.....	xviii (01)	106
regenerative (see Control, regenerative).		
relay system .....	xxviii (09)	940
rheostatic, limitations .....	xx (02)	118
rolling mill .....	xxviii (09)	901
series-parallel for printing press.....	xx (02)	143
single-phase railway .....	xx (02)	19
shunt repulsion motors .....	xxviii (09)	477, 515
teaser, boost and retard system, per- formance .....	xx (02)	175
method .....	xx (02)	121
time limit system .....	xxviii (09)	917
Ward Leonard system, disadvantages.....	xx (02)	191
performance .....	xx (02)	175
railway cars with auxiliary motors.....	xxiii (04)	754
regenerative, a. c. compared with d. c. ....	xxvi (07)	716
advantages .....	xxvi (07)	1482
for locomotives.....	xxvi (07)	1670
energy returnable .....	xxiv (05)	489, 514
induction motors, concatenated....	xviii (01)	656
tests .....	xxviii (09)	1313
Jungfrau three-phase railway.....	xviii (01)	119
methods .....	xxvi (07)	714
single-phase series motor arrange- ment .....	xxvi (07)	1472
single-phase series motors, com- pounding effect .....	xxvi (07)	1481
single-phase series motors, con- nections .....	xxvi (07)	1477
single-phase series motors, re- quirements .....	xxvi (07)	1470
tests on Vattellina line.....	xxiv (05)	490
three-phase motors at reduced speed .....	xviii (01)	121
value with three-phase system.....	xxiv (05)	486
speed (see Speed).		
effect on shop efficiency.....	xx (02)	123
machine tools, choice .....	xxix (10)	632

Control, ( <i>continued</i> )		
motor (see Control, motor).		
storage battery for locomotives.....	XXII (03)	120
switch, early Niagara plant.....	XXVIII (01)	491
Controllers, contactor type, advantages.....	XXVIII (09)	913
life of contacts.....	XXVIII (09)	902
machine tool, location .....	XXIX (10)	632
Convection, forced, effect of moisture.....	XXVIII (09)	386
tests .....	XXVIII (09)	378
losses from wires, forced ventilation, tests.....	XXVIII (09)	378
in free air, tests.....	XXVIII (09)	365
Converter, mercury arc, current control.....	XXV (06)	624
high-voltage .....	XXV (06)	632
instability .....	XXVIII (09)	18
life .....	XXVIII (09)	20
losses in constant current		
system .....	XXIV (05)	377
maximum e. m. f. ....	XXIV (05)	379
methods of starting .....	XXII (03)	82
operation, constant current		
system .....	XXIV (05)	373
theory .....	XXV (06)	601
oscillograms .....	XXIV (05)	381
parallel operation .....	XXV (06)	620
performance characteristics.....	XXV (06)	617
performance curves with mag-		
netite arc load.....	XXIV (05)	383
performance curves with mer-		
cury arc load .....	XXIV (05)	382
performance curves with non-		
inductive load .....	XXIV (05)	384
power factor .....	XXIV (05)	378
series operation .....	XXV (06)	622
short circuits .....	XXV (06)	625
single-phase, principle of opera-		
tion .....	XXII (03)	81
starting characteristics.....	XXV (06)	606
three-phase, principle of opera-		
tion .....	XXII (03)	78
transformation ratio.....	XXV (06)	623
volt-ampere, characteristic.....	XXV (06)	627
synchronous, a. c. booster inventor.....	XXVII (08)	245
regulation, advan-		
tages .....	XXVII (08)	231
type, cost .....	XXVII (08)	1053
efficiency .....	XXVII (08)	1053
floor space.....	XXVII (08)	1053
weight .....	XXVII (08)	1053
advantages over motor-genera-		
tors in railway work.....	XVIII (01)	610
analogy with auto-transformer.....	XXII (03)	18
armature reaction, advantages.....	XXIV (05)	734
armature reaction, effect on		
e. m. f. wave .....	XXII (03)	30
armature reaction, high vs.		
low .....	XXVII (08)	196
characteristic performance.....	XXIV (05)	725

Converter, synchronous, (*continued*)

- commutating poles, advantages and disadvantages .....XXIX (10) 1652
- commutating pole, use of dampers .....XXIX (10) 1674
- commutation (see Commutation).
- commutation, general discussion .....XXIX (10) 1625
- compared with motor-generator.XVIII (01) 611
- compounding .....XVIII (01) 609
  - advantages .....XXV (06) 554
  - disadvantages .....XXV (06) 550
  - effect on efficiency and cost..XXV (06) 550, 554, 556
  - methods.....XIX (02) 753; XXVII (08) 204
  - reasons .....XXV (06) 549
- cost .....XXIV (05) 719
  - compared with motor-generators...XVIII (01) 153; XXI (03) 436; XXVI (07) 309, 313
  - with induction regulator..XXVII (08) 1053
- design limitations .....XXIX (10) 1663, 1668
  - mechanical features.....XXIV (05) 729
- efficiency..XVIII (01) 138, 144; XXIV (05) 719; XXVI (07) 309, 316, 322, 329, 334, 674
- efficiency, all-year actual.....XXVII (08) 243
- efficiency, compared with motor-generators....XXI (03) 436; XXVI (07) 309, 316, 322, 329, 334
- efficiency, different loads.....XVIII (01) 151
  - railway service .....XXII (03) 269
  - with induction regulator .....XXVII (08) 1053
- e. m. f. drop permissible..XXIII (04) 785; XXIV (05) 1112
  - regulation, methods.....XXVII (08) 186
  - wave, calculation.....XXVII (08) 961
  - effect of armature reaction...XXII (03) 30
- floor space, with induction regulator .....XXVII (08) 1053
- four-ring, energy transformations, analysis .....XXII (03) 28
- frequency of maximum economy .....XXVI (07) 1400
- horizontal vs. vertical.....XXVII (08) 245
- hunting, causes .....XVIII (01) 607
  - effect of commutating poles .....XXIX (10) 1642
- induction regulator control, cost .....XXIV (05) 721
- inverted, use in railway work...XVIII (01) 605
- limitations in design.....XXIX (10) 1649
- load acceleration in railway service .....XVIII (01) 645
- multi-ring energy transformations, analysis .....XXII (03) 20

Converter, synchronous, (*continued*)

operation, effect of grounded		
neutral .....	XXIII (04)	350
overload capacity .....	XXII (03)	299; XXIV (05) 735
parallel operation .....	XXIV (05)	736
power-factor regulator .....	XXIII (04)	488
protection .....	XXIV (05)	257
short-circuit .....	XXIX (10)	1661
reactance, internal value .....	XXVII (08)	211
reactive loads, function .....	XXIV (05)	1110
reliability compared with motor		
generators .....	XXVI (07)	305, 320, 326, 328, 333, 342, 344, 347
requirements for interurban		
railway service .....	XXIX (10)	1657, 1667
self-starting, advantages .....	XXVII (08)	200
commutation characteristics .....	XXIX (10)	1676
short-circuit current, effect of		
commutating poles .....	XXIX (10)	1641
six-phase vs. three-phase .....	XXVII (08)	191, 246
speed, choice .....	XXIV (05)	723
standard, 25-cycle .....	XXIV (05)	718
60-cycle .....	XXIV (05)	718
split-pole, armature reaction .....	XXVII (08)	1044
commutation .....	XXVII (08)	1044
compared with other		
types .....	XXVII (08)	1053
cost .....	XXVII (08)	1053
efficiency .....	XXVII (08)	1053
floor space .....	XXVII (08)	1053
performance, actual		
service .....	XXVII (08)	1051
synchronous exciter,		
description .....	XXVII (08)	1012
three-part, e.m.f. wave		
calculation .....	XXVII (08)	976
three-part, e.m.f. wave		
oscillograms .....	XXVII (08)	999
three-part, theory .....	XXVII (08)	997
theory, physical explanation .....	XXVII (08)	1034
two-part, e.m.f. wave		
calculation .....	XXVII (08)	980, 1003
two-part, e.m.f. wave		
form .....	XXVII (08)	1024
two-part, e.m.f. wave		
improvement .....	XXVII (08)	1009
two-part, theory .....	XXVII (08)	1000
wave form .....	XXVII (08)	252
estimated .....	XXVII (08)	218
weight .....	XXVII (08)	1053
starting a. c. side .....	XXVII (08)	195
advantages .....	XXIV (05)	1083
disadvantages .....	XXIV (05)	1083



- Converter, synchronous, starting (*continued*)
- d. c. side, advantages....xxiv (05) 1080
  - disadvantages
    - xxiv (05) 1080, 1107
  - ease, compared with
    - motor-generators ..xxvi (07) 310
  - induction motor, advantages .....xxiv (05) 1081
  - induction motor, disadvantages .....xxiv (05) 1081
  - methods....xxiv (05) 1079, 1115; xxvii (08) 247
  - tests, early .....xviii (01) 455
  - three-phase vs. six-phase...xxvii (08) 191, 246
  - three-ring, energy transformations, analysis .....xxii (03) 25
  - transformation ratio .....xviii (01) 610
  - two-ring, energy transformations, analysis .....xxii (03) 23
  - use in railway work.....xviii (01) 607
  - vs. motor-generators, relative merits .....xxvi (07) 303
  - vertical bearings, construction..xxvii (08) 183
  - vs. horizontal .....xxvii (08) 245
  - voltage regulation, methods...xxvii (08) 186
  - weight with induction regulator .....xxvii (08) 1053
- Cooking, electric, cost compared with gas.....xxvii (08) 1605
- Cooling
  - alternators, ventilating spaces, dimensions.....xxiii (04) 271
  - conductors by thermal conduction.....xxvi (07) 973
  - curve, bare wire in sand.....xxvi (07) 990
  - forced ventilation, effect on current capacity of
    - wires, tests .....xxviii (09) 378
  - gas engines, jacket water required.....xxii (03) 795
  - system for large units.....xxix (10) 434
  - water required..xxvii (08) 1128; xxix (10) 433
  - oil, characteristics .....xxvi (07) 839
  - transformers, forced-oil, advantages.....xxvi (07) 846
  - amount water required .....xxvi (07) 836
  - DeCew Falls installation .....xxvi (07) 841
  - description .....xxvi (07) 835
  - disadvantages .....xxvi (07) 846
  - first installation.....xxvi (07) 849
  - saving .....xxvi (07) 836
  - forced-water, advantages.....xxvi (07) 845
  - self, limitations .....xxvi (07) 840
  - water, limitations .....xxvi (07) 840
  - operation with leak in
    - coil .....xxix (10) 725
  - water required for gas engines..xxii (03) 795; xxvii (08) 1128; xxix (10) 433
  - transformers .....xxvi (07) 836
- Cooper-Hewitt lamp (see Lamp, mercury vapor).
- work done on mercury vapor lamp.....xxii (03) 73

- Copper, cast, conductivity, electric.....xxii (03) 702  
 commercial, conductivity, electric.....xxii (03) 703  
     tensile strength .....xxii (03) 703  
 conductivity, electric, as measure of chemical  
     purity .....xxii (03) 695  
     at high temperatures.....xxix (10) 513  
     effect of antimony.....xxii (03) 696  
         arsenic .....xxii (03) 696  
         suboxid .....xxii (03) 696  
     relation to tensile strength.....xxii (03) 698  
     heat, at high temperatures.....xxix (10) 513, 536  
 elastic limit of cable.....xxiii (04) 513  
 electrolytic refining, current density.....xix (02) 284  
 energy reflected at different wave lengths.....xxix (10) 1723  
 expansion, temperature coefficient.....xxiii (04) 514  
 hand-drawn, elastic limit.....xxix (10) 989  
     expansion, temperature coefficient.....xxix (10) 989  
     modulus of elasticity.....xxix (10) 989  
     temperature coefficient of expansion .....xxix (10) 989  
     tensile strength .....xxix (10) 989  
 melting point .....xxiv (05) 625  
 micro-photographs of different grades.....xxii (03) 701  
 modulus of elasticity of wire.....xxiii (04) 514  
 one, low-grade, definition .....xix (02) 333  
     method of recovering.....xix (02) 334  
     plant for recovering description.....xix (02) 334  
 resistivity, electric, at high temperatures.....xxix (10) 513  
     heat, at high temperatures.....xxix (10) 513, 536  
 specific heat .....xxii (03) 283; xxiv (05) 625  
 temperature coefficient, electric resistivity.....xxix (10) 537  
     expansion .....xxiii (04) 514  
     heat resistivity.....xxix (10) 537  
 tensile strength of wire.....xxiii (04) 514  
 wire (see Wire).
- Copper-clad wire (see Wire).
- Cord-knotter, invention and evolution.....xxv (06) 530
- Core losses (see Iron losses).  
     test, effect of wave form on accuracy.....xxv (06) 708
- Cornell University, date of founding.....xxvi (07) 1434
- Corona, critical e. m. f. calculation.....xxvi (07) 169  
     conditions that affect.....xxviii (09) 788  
     discrepancy between Mershon  
         test and Ryan formula.....xxvii (08) 899  
     effect of conductor diameter.....xxix (10) 1173  
         form .....xxiii (04) 131  
         surface .....xxiii (04) 143  
     dirt .....xxix (10) 1174  
     light .....xxiii (04) 144  
     moisture .....xxix (10) 1176  
     stranding conductor.....xxvii (08) 920  
     temperature .....xxix (10) 1166  
         observed.....xxiii (04) 126  
     equation.....xxiii (04) 102; xxix (10) 1231  
     Mershon formula .....xxvii (08) 899  
         method of determination .....xxvii (08) 886  
     physical conception .....xxvii (08) 906

Corona, critical e. m. f. ( <i>continued</i> )		
Ryan formula .....	xxvii (08)	884
variation with conductor diam-		
eter .....	xxvii (08)	894
spacing .....	xxvii (08)	892
vapor product.....	xxvii (08)	894
intensity about conductor, measurement.....	xxix (10)	1162
point determination, Steinmetz method.....	xxvii (08)	913
diameter .....	xxix (10)	1181
effect of conductor diameter on dielectric		
strength of surround-		
ing air .....	xxix (10)	1215
length .....	xxviii (09)	783
surface condition.....	xxviii (09)	778
wave-form .....	xxviii (09)	775
formation, explanation .....	xxix (10)	1217, 1222
formula.....	xxiii (04) 102; xxviii (09) 774; xxix (10)	1231
in cables .....	xxiii (04)	145
oil .....	xxviii (09)	796
solid dielectrics .....	xxix (10)	1567
insulation thickness for various surface stresses,		
table .....	xxvi (07)	173
law for solid dielectrics.....	xxix (10)	1587
location on e. m. f. wave.....	xxix (10)	1179
loss, effect of conductor diameter.....	xxviii (01)	433
xxvii (08)		868
spacing .....	xxvii (08)	865
frequency .....	xxvii (08)	873
vapor product .....	xxvii (08)	861
measurement .....	xxvii (08)	915
stranded conductors .....	xviii (01)	436
wave form, effect .....	xviii (01)	434
needle-point hypothesis .....	xxix (10)	1574
phenomena, investigation .....	xxviii (09)	769
tests, critical point, determination.....	xxiii (04)	118
theory of stresses compared with actual.....	xxix (10)	1614
voltmeter (see Voltmeter).		
description .....	xxviii (09)	801
Corrosion, chemical, lead plates in salt solutions, tests.....	xxvi (07)	206
electrical, lead plates in salt solutions, tests.....	xxvi (07)	206
Corpuscles, effect on vacuum conduction.....	xxv (06)	767
nature .....	xxv (06)	766
Corundum, electrolytic production .....	xix (02)	292
Cosine, diagram of change with sine.....	xviii (01)	288
Cost, battery, storage .....	xx (02)	136
renewals .....	xx (02)	135
boiler maintenance .....	xxvi (07)	1718
operation .....	xxvi (07)	1718
brakes, maintenance .....	xx (02)	231
bushings, 44,000 volts .....	xxv (06)	880
catenary construction with light bridges.....	xxix (10)	986
concrete work with electric shovel.....	xxix (10)	370
cathode tubes .....	xxii (03)	548
coal handling, automatic .....	xxi (03)	458
hand .....	xxi (03)	458
coal-gas manufacture .....	xxii (03)	782
condensers, barometric .....	xxiv (05)	46
jet .....	xxiv (05)	49

Cost, condensers, (*continued*)

surface .....	XXIV (05)	46,	49
converters, split-pole .....	XXVII (08)		1053
synchronous .....	XXIV (05)		719
compared with motor-			
generators .....	XXVI (07)	309,	313
with a. c. booster .....	XXVII (08)		1053
induction regulator .....	XXVII (08)		1053
cooking, electric .....	XXVII (08)		1605
gas .....	XXVII (08)		1605
distribution d. c. ....	XXIV (05)		534
electric energy .....	XXIX (10)		132
three-phase .....	XXIV (05)		534
drive, electric, textile mills .....	XXIX (10)		385
mechanical, textile mills .....	XXIX (10)		386
energy, analysis .....	XXVIII (09)		1479
electric, effect of load curve .....	XXVIII (09)		1489
load-factor .....	XXII (03)	780; XXV (06)	
140; XXVIII (09)		1400, 1489	
estimation .....	XXIX (10)		116
gas-engine plants .....	XXVIII (09)		1484
steam-turbine plants .....	XXVIII (09)		1485
hydroelectric plants .....	XXVIII (09)		1486
with steam			
standby .....	XXVIII (09)		1381
in Germany .....	XXV (06)		38
New England .....	XXIX (10)		123
secondary, hydroelectric plant .....	XXV (08)		188
steam plant .....	XXV (06)		187
steam-engine plants .....	XXVIII (09)	1481; XXIX (10)	
III, II7			
exhaust-turbine			
plants .....	XXVIII (09)		1483
steam-turbine plants .....	XXVIII (09)		1482
transmission .....	XXIII (04)		769
variation with load-factor .....	XXVI (07)		1762
engine, gas, operation, actual .....	XXIX (10)		445
standby service .....	XXIX (10)		683
exciters, calculation .....	XXVII (08)		1454
fuel in Germany .....	XXV (06)		51
gas manufacture .....	XXII (03)		782
plant, operation .....	XXII (03)		788
storage .....	XXII (03)		771
generator, a. c., armature and field copper .....	XXVIII (09)		980
iron .....	XXVIII (09)		981
copper .....	XXVII (08)		1439
iron .....	XXVII (08)		1441
comparison, 25 and 60 cycles .....	XXVIII (09)		975
different sizes .....	XXVIII (09)		986
field copper .....	XXVII (08)		1436
high tension compared with me-			
dium tension .....	XXVI (07)	367,	369
pole material .....	XXVII (08)		1444
single-phase .....	XXIII (04)		97
three-phase .....	XXIII (04)		97
yoke material .....	XXVII (08)		1443
heating, electric, of large building .....	XXVII (08)		1602
textile mills, actual .....	XXIX (10)		388

Cost, (*continued*)

hot-water heater, coal .....	XXVII (08)	655
electric .....	XXVII (08)	655
inaccuracy of measuring instruments.....	XXVIII (09)	1277
insulator pins .....	XXIII (04)	544
line .....	XXIII (04)	544
locomotive, electric, operation and maintenance.....	XXVI (07)	1659
on mountain grades.....	XXVI (07)	1664
steam fuel .....	XXVI (07)	69
maintenance, for passenger and freight service .....	XXVI (07)	1682
operation and maintenance.....	XXVI (07)	1652
on mountain grades.....	XXVI (07)	1664
repairs.....	XXVI (07)	58, 67, 149
and maintenance, actual.....	XXVI (07)	112
Manhattan Elevated.....	XXVI (07)	58
passenger and freight service .....	XXVI (07)	1682
motor-generators compared with synchronous con- verters .....	XXVI (07)	309, 313
synchronous .....	XXIV (05)	719
pantagraph current collectors, maintenance.....	XXVII (08)	1637
pole lines, wooden, in California, actual.....	XXIX (10)	363
iron.....	XXI (03) 294; XXIII (04)	168, 526
steel .....	XXIII (04)	531, 532
wood .....	XXI (03) 294; XXIII (04)	168
power plants, electric, in California, actual.....	XXIX (10)	362
gas-electric .....	XXIX (10)	690
and gas plant combined.....	XXII (03)	788
estimated .....	XXII (03)	794
operation.....	XXII (03)	778, 781
gas-engine, Europe .....	XXV (06)	52
producer, estimated.....	XXVII (08)	1131
standby .....	XXIX (10)	679
hydroelectric, estimated .....	XXVIII (09)	1434
construction, actual.....	XXV (06)	186
New England.....	XXVIII (09)	1406
operation, actual.....	XXV (06)	186
proportional part of various equipment.....	XXVIII (09)	1396
repairs, electric .....	XXVIII (01)	658
railway, d. c. ....	XXIV (05)	538
three-phase .....	XXIV (05)	538
steam, New England.....	XXVIII (09)	1407
steam-electric, estimated .....	XXII (03)	794
operation .....	XXII (03)	778
steam-engine-exhaust-turbine opera- tion, actual .....	XXVI (07)	1761
steam-turbine, estimated .....	XXVII (08)	1131
Ft. Wayne double- deck station.....	XXVII (08)	1117
standby .....	XXIX (10)	679
West Point double- deck station.....	XXVII (08)	1119
radium .....	XIX (02)	70
rail bonds, installation .....	XXIV (05)	89
railways, electric, a. c., 25 and 15 cycles.....	XXVI (07)	131
6,600-volt .....	XXVI (07)	390

Cost, railways, electric, a. c. (*continued*)

equipment, induction motor	
with concatenated control.	xviii (01) 625
equipment, induction motor	
with rheostatic control.	xviii (01) 625
single-phase equipment compared with d. c. equipment	.....xxvii (08) 1164
three-phase.	.....xxiv (05) 472, 508, 538
installation	.....xxiv (05) 471
operation, Val-	
tillina line.	.....xxiv (05) 501
overhead main-	
tenance	.....xxiv (05) 479
power plant.	.....xxiv (05) 538
d. c.	.....xxiv (05) 472, 508, 538
600-volt	.....xxvi (07) 390
1200-volt	.....xxvi (07) 390
compared, single-phase.	xxvi (07) 776, 776
construction, 600-volt	.....xxix (10) 9
1200-volt	.....xxix (10) 9
equipment	.....xviii (01) 625
repairs	.....xxvi (07) 60
maintenance, 600-volt.	.....xxix (10) 11
1200-volt.	.....xxix (10) 11
operation, 600-volt	.....xxix (10) 11
1200-volt	.....xxix (10) 11
power house	.....xxiv (05) 538
interurban.	xxiii (04) 98; xxiv (05) 1067; xxvi (07) 390
narrow-gauge, esti-	
mate	.....xxiv (05) 1072
operation	.....xxvi (07) 390
single-phase	.....xxiii (04) 98
operation	.....xxvi (07) 46
actual	.....xxvi (07) 141
suspended monorail, construction.	xviii (01) 58
steam, electrification.	.....xxvi (07) 808, 1396, 1684
operation	.....xxvi (07) 46
track construction	.....xxvi (07) 1684
secondary power	.....xxv (06) 188
selenium	.....xxi (03) 392
slashing, actual	.....xxix (10) 388
substation attendance	.....xviii (01) 647
outdoor and indoor transformer.	.....xxviii (09) 230
railway direct-current	.....xxiv (05) 535
three-phase	.....xxiv (05) 535
synchronous converter	.....xxiv (05) 1106
switches, group	.....xxiii (04) 202
oil, manual control.	.....xxvi (07) 870
telephone, automatic, central, operation, maintenance	
and repairs	.....xxvii (08) 518
central office equipment, automatic.	.....xxvii (08) 508
manual and	
automatic	.....xxvii (08) 511
operation, maintenance and	
repairs	.....xxvii (08) 518
plant, analysis	.....xxvii (08) 504

- Cost, telephone, plant, (*continued*)
- common-battery, automatic .....xxvii (08) 505
  - manual .....xxvii (08) 505
  - operation.....xxix (10) 91
  - trouble labor, manual and automatic
  - systems .....xxvii (08) 527
  - train lighting, acetylene system.....xxi (03) 208
  - axle-driven .....xxi (03) 209
  - batteries .....xxi (03) 176
  - electric system .....xxi (03) 208
  - oil system .....xxi (03) 208
  - Pintch gas system.....xxi (03) 208
  - transformers, polyphase vs. single-phase.....xxvi (07) 814
  - transmission towers.....xxiii (04) 531; xxvi (07) 191
  - footings .....xxvi (07) 1236
  - line relation to length of span.....xxvi (07) 1233
  - relation to width of base.....xxvi (07) 1232
  - turbine, steam, low-pressure.....xxv (06) 36
  - operation, standby service.....xxix (10) 683
  - water tunnels .....xxv (06) 154
  - water-gas manufacture .....xxii (03) 782
  - watt-hour meter installation as affected by diversity-  
    factor .....xxix (10) 383
  - Cotton industry in South, growth.....xxiv (05) 802
  - mills (see Textile mills).
  - Cowper and Robertson writing telegraph (see Telegraph,  
    writing).
  - Crank diagram representation of alternating quantities,  
    objections .....xxix (10) 1271
  - Creplet electric hoisting system.....xxix (10) 281
  - Cross-arm construction, practice .....xxiii (04) 583
  - high-tension, methods of fastening.....xxiii (04) 575
  - metal vs. wood, with reference to lightning  
        disturbances .....xxvii (08) 699
  - wood vs. metal, with reference to lightning  
        disturbances .....xxvii (08) 699
  - Crossings, telegraph lines and transmission lines.....xxix (10) 913
  - telephone lines and transmission lines.....xxix (10) 913
  - transmission lines, Southern Pacific R. R.  
        specifications .....xxix (10) 906
  - specifications.....xxix (10) 906, 916,  
            919, 921
  - value of wire net.....xxix (10) 911
  - with railroads and high-  
            ways .....xxiii (04) 576
  - Current, 100,000-cycle, physiological effects.....xxviii (09) 413
  - alternating, high-frequency, measurement.....xxix (10) 1548
  - density, copper, electrolytic refining.....xix (02) 284
  - generator, a. c., armature, low-speed.....xxii (03) 47
  - nickel-plating .....xix (02) 282
  - d. c. measurement, large values.....xviii (01) 171
  - electrolytic, measurement without electrodes.....xix (02) 314
  - measurement in electrolyte without electrodes.....xix (02) 372
  - meters (see Ammeters).
  - production in electrolyte without electrodes.....xix (02) 312
  - rectified, types of instruments suitable.....xxiv (05) 395
  - reverser for locating cable faults, construction...xviii (01) 831
  - transformer (see Transformer, series).

- Current, (*continued*)  
     wave tracer, description .....XIX (02) 1123  
         Owens type, advantages.....XIX (02) 1125
- Current-carrying capacity, bare wire in gravel.....XXVI (07) 986  
     sand .....XXVI (07) 986  
     soil .....XXVI (07) 986  
     cables .....XXVI (07) 559  
         in ducts..XXII (03) 440; XXIV (05) 409  
     collector shoes .....XXIX (10) 1033  
     rubber-covered wire, tests.....XXVI (07) 978  
     rubber-covered wires in mold-  
         ing .....XXVI (07) 985  
     rubber-covered wires in mold-  
         ing, tests .....XXVI (07) 982  
     rubber-covered wires, given  
         temperature rise .....XXVI (07) 980  
     wires at different air pres-  
         sures .....XXVIII (09) 373  
     wires at different air veloci-  
         ties .....XXVIII (09) 384  
     wires cooled by conduction,  
         formula .....XXVI (07) 993  
     wires, investigation .....XXVIII (09) 363
- Current-collector, 10,000 volts .....XIX (02) 517  
     high-tension .....XXIX (10) 1006  
     Huber system.....XXIV (05) 104, 152; XXVI (07) 724  
     pantagraph maintenance, cost N. Y.,  
         N. H. & H. R. R.....XXVII (08) 1637  
     rollers, life .....XXIX (10) 1008, 1033  
     shoes, life...XXVII (08) 1639, 1697; XXIX  
         (10) 1008  
     shoe, current capacity.....XXIX (10) 1033  
         pressure .....XXIX (10) 1026  
     sliding bow, advantages.....XXIX (10) 977  
         pressure .....XXVII (08) 1704  
     three-phase, 10,000 volts .....XIX (02) 517  
     Valtellina railway .....XXIV (05) 102
- Curve tracer for speed variation measurement.....XIX (02) 1128
- Curves, railway, offset for catenary construction.....XXIX (10) 981
- Cycles, air, isobaric .....XXVIII (09) 78  
     isothermic .....XXVIII (09) 75, 77  
     gas, efficiency .....XXVIII (09) 86, 97  
     steam, condensing .....XXVIII (09) 81  
         non-condensing .....XXVIII (09) 80  
     thermo-dynamic, efficiency .....XXVIII (09) 74
- Dampers action .....XVIII (01) 786  
     losses .....XVIII (01) 786
- Daylight, color composition .....XXIX (10) 1726
- Deceleration (see Retardation).
- Decentralized plants, advantages .....XXIX (10) 174  
     definition .....XXIX (10) 153  
     Rochester Ry. & Light Co. ....XXIX (10) 153
- DeCew Falls forced-oil cooling system for transformers,  
     description .....XXVI (07) 841
- Deflocculated graphite, description.....XXVI (07) 1363
- DeForrest wave detector (see Audion).



- DeLaval steam turbine (see Turbine).  
     description .....xviii (01) 90
- Depreciation, hydroelectric plants.....xxviii (09) 1377, 1394, 1424  
     calculation.....xxviii (09) 1424  
     power house equipment.....xxviii (09) 1397  
     substations .....xxviii (09) 1398  
     telephone plant, automatic system....xxix (10) 89, 93, 98  
     transmission line .....xxviii (09) 1398
- Dialysis, definition .....xix (02) 358
- Dielectrics, bibliography .....xxix (10) 1580  
     breakdown, effect of local heating.....xxix (10) 1592  
     brush discharge, effect on insulation quality...xxii (03) 356  
     conductance, effect of stress distribution....xxix (10) 1564  
     laws .....xxix (10) 1607  
     corona phenomena (see Corona).  
     early experiments on dielectric strength.....xxix (10) 1608  
     energy conversion into chemical action.....xxvi (07) 1022  
     heating caused by potential strains.....xxii (03) 354  
     ionization theory .....xxix (10) 1582  
     loss, formula .....xxvi (07) 961, 998  
     losses, variation with e. m. f. ....xix (02) 1056  
         frequency .....xix (02) 1056  
         temperature .....xix (02) 1055  
     phenomena, electronic theory.....xxvi (07) 960  
     potential strains, classification.....xxii (03) 354  
         stresses, general discussion.....xxix (10) 1553  
     saturation .....xxvi (07) 962  
     strength, effect of fatigue.....xxii (03) 367  
         over-strains .....xxix (10) 1618  
     tests .....xxii (03) 353  
     time element .....xviii (01) 423  
     various apparatus (see Name of apparatus).  
     substances (see Name of substance).  
     with transient voltage, experimental  
         study .....xxix (10) 1125
- stress, corona theory compared with actual  
     phenomena .....xxix (10) 1614  
     distribution, mechanical analogy.....xxix (10) 1587  
     mechanical action .....xix (02) 1069  
     temperature, effect on performance.....xix (02) 1050  
     testing, choke coils, uses.....xxii (03) 361  
         e. m. f. application methods.....xxii (03) 365  
         measurement .....xxii (03) 365  
         precautions .....xxii (03) 357  
         spark gap, danger in use.....xxii (03) 361
- Discharges, disruptive, energy, estimation.....xxix (10) 1144  
     distance, effect of electrode shape with tran-  
         sient e. m. f.'s .....xxix (10) 1155  
         relation to energy.....xxix (10) 1149  
     spark lag, tests .....xxix (10) 1215
- Dischargers, static (see Lightning arresters).  
     effect on transmission lines.....xxvii (08) 423
- Disruptive discharge (see Discharge).  
     disturbance of telephone and tele-  
         graph lines .....xxviii (09) 1190  
     electromagnetic disturbances.....xxviii (09) 1190
- Distance measurement in railway tests.....xx (02) 225
- Distance-time curves, plotting.....xix (02) 937

Distribution, 500-volt three-wire, disadvantages.....	XVIII (01)	862
500-volt vs. 250-volt, three-wire systems.....	XVIII (01)	863
a. c., advantages for outskirts.....	XVIII (01)	859
of transformers between circuits and transmis- sion line .....	XVIII (01)	841
over d. c. ....	XVIII (01)	844
apparatus required .....	XVIII (01)	846
development .....	XVIII (01)	849
directions for grounding neutral.....	XXVI (07)	178
effect of superposed d. c. ....	XXVIII (09)	729
electrostatic disturbances .....	XXVIII (09)	1190
ground as return .....	XXVI (07)	1588
grounded neutral effect on telephone and telegraph lines .....	XXVIII (09)	1195
inductive disturbances, calculation.....	XXVIII (09)	1206
losses compared with d. c. system.....	XXVI (07)	675
protection against surges.....	XXIV (05)	355
regulation storage battery, uses.....	XXVII (08)	987
requirements for success .....	XVIII (01)	853
single-phase four-wire generator.....	XVIII (01)	808
losses .....	XVIII (01)	903
three-phase generators.....	XVIII (01)	806
three-wire, from three- phase generator.....	XVIII (01)	809
suburban, construction .....	XXII (03)	736
three-phase, correction for unbalance.....	XXVI (07)	1373
four-wire, three-phase gen- erator .....	XVIII (01)	810
three-wire, losses .....	XVIII (07)	903
typical layout .....	XXIV (05)	256
transformers (see Transformers). methods of paralleling.....	XVIII (01)	850
two-phase four-wire, losses.....	XVIII (01)	903
three-wire, losses .....	XVIII (01)	903
use of storage battery.....	XVIII (01)	875
arc light, constant-current mercury rectifier, performance characteristics .....	XXIV (05)	382
arc light, constant-current mercury rectifier, losses .....	XXIV (05)	377
arc light, constant-current mercury rectifier, oscillograms .....	XXIV (05)	381
arc light, constant-current mercury rectifier, power-factor .....	XXIV (05)	378
cable, high-tension, Buffalo, description.....	XVIII (01)	835
general layout.....	XVIII (01)	838
natural frequencies, actual.....	XXVIII (09)	827
relation to length of cable.....	XXVIII (09)	838
relation to number of cables.....	XXVIII (09)	835
surges, oscillograms .....	XXVIII (09)	811
relation between current to ground and e. m. f. across potential regulator.....	XXVIII (09)	837
tests .....	XXVIII (09)	809
central station system, losses.....	XXVI (07)	665

Distribution, (*continued*)

choice of system .....	XXI (03)	408
circuits (see Circuits).		
phase shift (see Phase).		
unbalanced, commercial aspects.....	XXVIII (09)	579
regulating effect of in-		
duction and synchro-		
nous motors .....	XXVIII (09)	585
voltage unbalance (see Voltage).		
city, advantages a. c. system for outskirts.....	XVIII (01)	859
d. c. system for business		
section .....	XVIII (01)	858
business section .....	XVIII (01)	858
general problem .....	XVIII (01)	855
load per square mile.....	XVIII (01)	863
miles of streets per square mile.....	XVIII (01)	863
outskirts .....	XVIII (01)	859
storage battery for two or more e.m.fs.....	XVIII (01)	820
value .....	XVIII (01)	820, 822
territory economically covered.....	XVIII (01)	865
cost from central plant compared with iso-		
lated plants .....	XXIX (10)	132
d. c., advantages for business section.....	XVIII (01)	858
over a. c. ....	XVIII (01)	844
apparatus required .....	XVIII (01)	846
losses compared with a. c. system.....	XXVI (07)	675
three-wire, advantages for variable speed		
motors .....	XX (02)	133
two-wire, losses .....	XVIII (01)	903
efficiency, Chicago Edison Co. ....	XVIII (01)	899
feeders (see Feeders).		
high-tension, advantages .....	XXIX (10)	553
e. m. f. regulation .....	XXIX (10)	570
fed from several plants, e. m. f.		
regulation .....	XXIX (10)	570
suburban, construction .....	XXII (03)	736
lighting, maximum size motor allowed.....	XVIII (01)	856
lines, construction .....	XXII (03)	748
location of protective devices.....	XXII (03)	750
mechanical specifications .....	XXII (03)	748
suburban .....	XXII (03)	736
local system, Niagara Falls Power Co. ....	XVIII (01)	505
losses, various systems .....	XVIII (01)	903
railway, a. c. electrolysis pipes and cables.....	XXIV (05)	519
impedance, calculation .....	XXVII (08)	1146
tests; one, two and		
four-track roads.....	XXVII (08)	1171
reactance of circuit.....	XXVII (08)	1144
single-phase, choice of e. m. f.....	XXIV (05)	116
single-phase, circuit breaker		
performance .....	XXVII (08)	1621
single-phase, disturbance of		
telephone and telegraph		
lines, neutralizing device,		
disadvantages .....	XXVIII (09)	1234
single-phase, drop, actual.....	XXIX (10)	15
single-phase, effect of fre-		
quency .....	XXVI (07)	1381

Distribution, railway, a. c. (*continued*)

- single-phase, efficiency at different load-factors .....xxvi (07) 1658
- single-phase, inductance .....xxviii (09) 1238
- single-phase, losses .....xxiv (05) 537
- single-phase, neutralizing conductors, against telephone and telegraph disturbances.....xxviii (09) 1204
- single-phase, N. Y. N. H. & H. R. R., neutralizing apparatus, short-comings.....xxviii (09) 1234
- single-phase, N. Y. N. H. & H. R. R. system.....xxvii (08) 43
- single-phase, sectionalization...xxvii (08) 47
- single-phase, sectionalization, length of sections.....xxvii (08) 58
- single-phase, single-track.....xxvii (08) 59
- single-phase, systems .....xxvii (08) 43
- single-phase, telegraph disturbances, defects in neutralizing transformers .....xxvii (08) 1684
- single-phase, three-phase system.....xxvi (07) 1369
- single-phase, trolley wire wear.....xxvii (08) 1697
- single-phase, two-phase system.....xxvi (07) 1370
- single-phase, typical systems...xxviii (09) 1203
- single-phase, use of storage battery .....xxvii (08) 992
- single-phase vs. three-phase.....xxiv (05) 513
- three-phase, cost.....xxiv (05) 472, 534, 535
- three-phase, disadvantages of double trolley.....xxviii (09) 1335, 1353
- three-phase, Great Northern, construction .....xxviii (09) 1301
- three-phase, Great Northern, description .....xxviii (09) 1337
- three-phase, Great Northern, efficiency .....xxviii (09) 1313
- three-phase, losses.....xxiv (05) 473, 537
- three-phase, maintenance, cost...xxiv (05) 479
- three-phase, maximum drop.....xix (02) 550
- three-phase vs. single-phase.....xxiv (05) 513
- wiring plan .....xxiii (04) 94
- annual charges, calculation.....xxvii (08) 1205
- battery calculations .....xxiii (04) 393
- boosters, performance tests...xxii (03) 254; xxvii (08) 1206
- catenary (see Catenary).
- copper calculation by Kelvin's law...xxiv (05) 1106
- d. c., cost .....xxiv (05) 472, 534
- efficiency .....xix (02) 849
- at different load-factors .....xxvi (07) 1658
- losses .....xxiv (05) 473
- wiring plan .....xxiii (04) 96
- double trolley, disadvantages...xxviii (09) 1335, 1353
- effect of locomotive blast on insulation .....xxvii (08) 1620

Distribution, railway, (*continued*)

effect of locomotive blast on steel		
wire .....	XXVII (08)	1705
efficiency.....	XVIII (01) 899; XXII (03)	251, 500
average .....	XXVI (07)	398
feeders, equivalent of substation....	XXIX (10)	5
requirements, 600 and 1200-		
volt d. c. ....	XXIX (10)	8
friction and electrical losses.....	XXII (03)	496
losses, causes .....	XXVII (08)	1207
maintenance cost in Europe, actual....	XXIV (05)	147
Mayer system of overhead construc-		
tion .....	XXVI (07)	723
resistance tests; one, two and four-		
track roads .....	XXVII (08)	1171
reverse power relays on feeders.....	XXII (03)	439
standard location of contact con-		
ductors .....	XXVI (07)	135
storage battery and booster calcula-		
tions .....	XXII (03)	720
calculations .....	XXII (03)	708
performance tests....	XXII (03)	252
strain insulators (see Insulators).		
breakdown e. m. f....	XXII (03)	239
composition .....	XXII (03)	240
e. m. f. breakdown		
tests .....	XXII (03)	234
insulation resistance		
tests .....	XXII (03)	237
specifications....	XXII (03)	239, 241
tensile strength....	XXII (03)	239
tensile strength,		
tests .....	XXII (03)	232
stray currents (see Stray currents).		
methods of reducing....	XXVI (07)	247
synchronous converter requirements....	XXIX (10)	1657, 1667
third rail (see Third rail).		
three-wire experience, Boston.....	XXVI (07)	269
trolley insulators, heating tests.....	XXII (03)	235
uses of storage battery.....	XXII (03)	706
sectional system .....	XXI (03)	435
system, Berlin, Germany.....	XVIII (01)	826
Buffalo high-tension cable.....	XVIII (01)	835
Cataract Power & Conduit Co.,		
description .....	XVIII (01)	840
Chicago, map .....	XVIII (01)	824
diversity-factor of various parts.....	XXIX (10)	380
grounded neutral, method of con-		
necting star-connected generators....	XXIX (10)	805
insulators (see Insulators).		
laying out, general rules.....	XVIII (01)	810
meters cost, effect of diversity-		
factor .....	XXIX (10)	383
Milan, Italy .....	XVIII (01)	827
protection, reverse power system,		
advantages .....	XXII (03)	303

Distribution, system, ( <i>continued</i> )		
United Electric Light & Power Co.,		
New York .....	XXVIII (09)	805
telephone, circle type pole-top construction....	XXVI (07)	587
interior block method .....	XXVI (07)	580
unbalanced circuits (see Circuits).		
underground, device for automatic selection		
of defective cables.....	XXVI (07)	1619
fault location .....	XVIII (01)	829
manhole spacing .....	XVIII (01)	830
trouble, nature .....	XXI (03)	427
Diversity-factor, analytical discussion .....	XXIX (10)	375
between various parts of distribution		
system .....	XXIX (10)	380
commercial districts .....	XXIX (10)	378
definition .....	XXIX (10)	376
effect of centralization of energy		
supply .....	XXVIII (09)	358
on central station initial invest-		
ment .....	XXIX (10)	383
cost of meter equipment....	XXIX (10)	383
residence districts .....	XXIX (10)	378
Double-deck turbine plant (see Power plants).		
Drafting rooms, lighting .....	XXIX (10)	143
Dredges, gold, construction .....	XXII (03)	508
first in U. S. ....	XXII (03)	510
operation, method .....	XXII (03)	507
power requirements .....	XXII (03)	512
wiring .....	XXII (03)	516
suction, power requirements .....	XXIX (10)	366
Drysdale stroboscopic fork, description....	XXVII (08)	632
Duddell oscillograph, description .....	XXIV (05)	197
Duplex telegraph (see Telegraph).		
Dust, fire risk .....	XXIII (04)	175
Dynamometer car, horse-power calculation from draw		
bar pull .....	XIX (02)	876
Illinois Railway Co., description....	XIX (02)	867
tests, suburban road .....	XIX (02)	879
torsion spring, construction....	XXII (03)	448
Dynamite for use in salt water.....	XIX (02)	730
handling, damaged .....	XIX (02)	731
Ear, natural period of vibration.....	XXVIII (09)	1187
Earth currents (see Stray currents).		
resistance, tests .....	XXVII (08)	723
Eddy-currents in armature conductors, density.....	XXIV (05)	764
effect of lamina-		
tion .....	XXIV (05)	770
loss factors.....	XXIV (05)	772
magnitude .....	XXIV (05)	762
phase .....	XXIV (05)	764
exponent, variation with flux density..	XXVIII (09)	455,
loss, variation with flux density.....	XXVIII (09)	458,
frequency .....	XXVIII (09)	462
Edison central station, date of first.....	XXI (03)	173
Electric Co. (Cal.) high-pressure hydroelectric		
plant, description .....	XXII (03)	627
X-Ray lamps .....	XXI (03)	337

- Education, Casino Technical Night School, scope of  
     work .....xxviii (09) 1099  
     classics, value...xxviii (09) 1108, 1112, 1115, 1117, 1125, 1127  
     concentric method .....xxvi (07) 1441  
         proposed engineering  
         courses .....xxvi (07) 1448  
     co-operative, advantages .....xxvii (08) 1488  
         course between college and fac-  
         tory, outline .....xxvii (08) 1466  
         disadvantages...xxvii (08) 1480, 1483, 1484, 1488  
         outline .....xxvii (08) 1466  
     course suggested for electrical engineers...xxviii (09) 1130  
     criticism, engineering graduates...xxii (03) 584  
     derivation of word .....xxii (03) 615  
     electrical courses, classification...xxii (03) 605  
         requirements .....xxii (03) 602  
         engineering (see Education, engineering).  
     engineering, college courses, inefficiency,  
         reasons .....xix (02) 1147  
         defects in American system...xxvii (08) 80  
         design, value...xix (02) 1184, 1191  
         electrical...xix (02) 1165; xxii (03) 570  
             course outline...xix (02) 1165  
             ideal .....xix (02) 1149  
         English .....xxii (03) 609  
         examinations, value...xix (02) 1178, 1188  
         functions .....xxii (03) 581  
         fundamental subjects, time  
             devoted .....xix (02) 1153  
         ideal .....xxvii (08) 69, 103  
         course .....xix (02) 1157  
         methods, Columbia Univ...xxvi (07) 1457  
             Lehigh Univ...xxvi (07) 1461  
             Univ. of Michigan...xxvi (07) 1462  
         modern methods, faults...xxii (03) 615  
         relation of mathematics...xxvii (08) 86, 101  
         thesis, function .....xix (02) 1163  
     General Electric apprenticeship course, de-  
     scription .....xxvii (08) 1462  
     historical outline of technical schools in U. S...xxvi (07) 1432  
     industrial, actual results of Newark Tech-  
         nical Night School...xxviii (09) 307  
     co-operative .....xxviii (09) 269  
         Fitchburg, Mass...xxviii (09) 273  
         principles .....xxviii (09) 273  
         Univ. of Cincinnati...xxviii (09) 274  
     fundamental principles .....xxviii (09) 269  
     lecture course, outline for em-  
         ployees .....xxviii (09) 303  
     scope of problem...xxviii (09) 270  
     Univ. of Wisconsin...xxviii (09) 289  
     instruction, seminary method...xix (02) 1162  
     languages, classic, value...xxviii (09) 1104  
         modern, value...xxviii (09) 1108, 1124, 1127  
     manufacturing engineer .....xxii (03) 590  
     night schools, field of usefulness...xxviii (09) 1101  
     number of children in schools of U. S...xxviii (09) 269  
     physics, instruction from college standpoint...xix (02) 1176

Education, (*continued*)

relation of manufacturer to graduates..XXVII (08)	1473, 1477
suggested modifications of present college systems .....	XXIX (10) 660
training non-technical men.....	XXVIII (09) 1095
Efficiency, battery, storage, differential booster.....	XXII (03) 734
railway substation service.....	XXII (03) 276
boiler, effect of combustion rate.....	XXVI (07) 1723, 1734
ratio of grate area to heating surface .....	XXVI (07) 1721
velocity of gases.....	XXVI (07) 1726
relation to carbon dioxide in flue gas.....	XXVI (07) 1773
flue gas temperature.....	XXVI (07) 1773
central station plant.....	XXIX (10) 341
converters, split-pole .....	XXVII (08) 1053
synchronous.....	XVIII (01) 138, 144; XXIV (05) 719;
XXVI (07) 309, 316, 322, 329, 334, 674	
a. c. booster.....	XXVII (08) 1053
different loads.....	XVIII (01) 151
induction regulator.....	XXVII (08) 1053
railway service.....	XXII (03) 269
distribution, Chicago .....	XVIII (01) 899
railway .....	XVIII (01) 899
d. c., different load-factors .....	XXVI (07) 1658
generation and transmission .....	XXII (03) 496, 500
generators to cars.....	XXVI (07) 398
interurban .....	XXII (03) 251
single-phase, different load-factors .....	XXVI (07) 1658
elevators, electric .....	XIX (02) 482
energy, incandescent lamps .....	XXV (06) 789
engine, gas .....	XVIII (01) 78
actual .....	XXII (03) 768
steam .....	XVIII (01) 78
flywheels .....	XXIX (10) 1386
generators, a. c. high-tension .....	XXVI (07) 367
medium-tension .....	XXVI (07) 367
acyclic .....	XXIV (05) 13
Niagara .....	XVIII (01) 481
No. 1 .....	XVIII (01) 476
method of estimating.....	XVIII (01) 481
heating, coal gas .....	XXVII (08) 1591
stove .....	XXVII (08) 1605
kinetic, definition .....	XXV (06) 56
light radiation from vapors.....	XXV (06) 862
lamps, incandescent, energy.....	XXV (06) 789
Moore carbon-dioxide tube.....	XXVI (07) 620
nitrogen tube .....	XXVI (07) 621
locomotive, electric, N. Y. C. ....	XXIV (05) 503
three-phase .....	XXIV (05) 523
Valtellina.....	XXIV (05) 503, 523
luminous, of radiation.....	XXVI (07) 965
machines, synchronous, in parallel, equation.....	XXVI (07) 1038
Moore carbon-dioxide tube.....	XXVI (07) 620
nitrogen tube .....	XXVI (07) 621



Efficiency, (*continued*)

motors, d. c., different sizes.....	xviii (01)	904
elevator .....	xix (02)	482
induction, different sizes.....	xviii (01)	905, 907
railway, d. c. ....	xix (02) 158; xxvi (07)	790
induction .....	xviii (01)	614
single-phase .....	xxvi (07)	790
repulsion .....	xxiii (04)	2
motor-generators.....	xviii (01) 138; xxvi (07)	674
a. c. ....	xviii (01)	144
d. c. ....	xviii (01)	144
different loads .....	xviii (01)	151
induction...xxvi (07) 309, 316, 322, 329, 334		
synchronous...xxiv (05) 719; xxvi (07) 309, 316, 322, 329, 334		
Pelton wheel .....	xxii (03)	630, 632
power-plant, effect of accurate instruments....	xxv (06)	28
hydroelectric, high-pressure.....	xxii (03)	646
railway, electric .....	xix (02)	849
rectifiers .....	xviii (01)	144
telephone plant .....	xxi (03)	79
thermal, gas engine .....	xxix (10)	686
steam-electric power plant.....	xxii (03)	497
various gas producers.....	xxii (03)	776
train lighting, axle-driven.....	xxi (03)	194
engine-driven .....	xxi (03)	194
transmission, d. c. compared with three-phase. xviii (01) 648		
line .....	xxii (03)	250
effect of reactive load.....	xviii (01)	340
plant, Buffalo-Niagara Falls....	xviii (01)	524
three-phase compared with d. c....	xviii (01)	648
turbines, steam, low pressure, effect of nozzle pressure .....	xxix (10)	243
Eickemeyer a. c. series motor, design constants.....	xxiii (04)	11
performance character-istics .....	xxiii (04)	12
Elastic limit, various materials (see Name of material).		
Electric field (see Field).		
Electrical Development Co. power plant, description.....	xxiv (05)	808
substation, description.....	xxiv (05)	821
water turbines, description.....	xxiv (05)	815
Testing Laboratories, work done.....	xxiv (05)	1051
Electricity, advantages on war ship.....	xix (02)	581
fire hazard .....	xxvii (08)	471
French navy .....	xix (02)	583
German navy .....	xix (02)	582
Russian navy .....	xix (02)	582
wave propagation .....	xix (02)	570
Electrochemical process, development, evolution theory....	xix (02)	354
Electrodes, furnace, carbon, performance tests.....	xxix (10)	505
copper, performance tests.....	xxix (10)	514
design .....	xxix (10)	515
principles .....	xxix (10)	486
graphite, performance tests.....	xxix (10)	509
iron, performance tests.....	xxix (10)	510
pinch effect .....	xxix (10)	511
losses, Hering's laws.....	xxix (10)	465, 492
investigation, experimental....	xxix (10)	485

- Electrodes, furnace, (*continued*)  
     size and losses for different materials .....XXIX (10) 528  
     temperature distribution .....XXIX (10) 476  
     high-tension, effective resistance .....XXIX (10) 1224  
         size .....XXIX (10) 1223
- Electrodynamometer, absolute, design data .....XXII (03) 523  
     power-factor meter, principles .....XVIII (01) 296  
     use in testing instrument trans-  
         formers .....XXIX (10) 1544  
         water-cooled .....XXIX (10) 1547
- Electrolysis (see Stray currents).  
     a. c., effect of current density .....XXVI (07) 207  
         different soils .....XXVI (07) 212  
         temperature .....XXVI (07) 220  
     experimental investigation .....XXVI (07) 201  
     laboratory tests .....XXVI (07) 281  
     lead plates and salt solutions, tests .....XXVI (07) 203  
         protection by superposition of  
             direct current .....XXVI (07) 223  
             pipes and cables .....XXIV (05) 519  
             protection of lead .....XXVI (07) 299  
     cables, bonding sheaths to negative bus,  
         experience .....XXVI (07) 301  
         effect of grounding sheaths .....XXV (06) 205  
         protection .....XXVI (07) 299  
             insulating joints .....XXV (06) 206  
             insulation .....XXVI (07) 300  
     iron imbedded in concrete, tests .....XXVI (07) 232
- Electrolyte, current measurement without electrodes .....XIX (02) 314  
     production without electrodes .....XIX (02) 312
- Electromagnetic induction (see Induction).
- Electrometer advantages .....XIX (02) 1035  
     disadvantages .....XIX (02) 1036  
     high-tension, construction .....XXIII (04) 137  
     quadrant power measurement .....XIX (02) 1040  
     torque, calculation .....XIX (02) 1036
- Electrons, charge .....XXVI (07) 940  
     measurement, method .....XXVI (07) 940  
     mass .....XXVI (07) 937  
     measurement, method .....XXVI (07) 941  
     properties .....XXVI (07) 937  
     size .....XXVI (07) 946
- Electrophysics, dielectric saturation .....XXVI (07) 962  
     dumb-bell molecule, definition .....XXVI (07) 961  
     electrons (see Electrons).  
     electronic theory, contact e. m. f. ....XXVI (07) 956  
         dielectric phenomena .....XXVI (07) 960  
         electric conduction .....XXVI (07) 952  
         electromagnetic induc-  
             tion .....XXVI (07) 957  
         Hall effect .....XXVI (07) 958  
         thermal conduction .....XXVI (07) 954  
         thermo e. m. f. ....XXVI (07) 957  
     radiation laws (see Radiation).
- Electroplating, critical current density, definition .....XIX (02) 283  
     processes .....XIX (02) 281
- Electroscope, Curie's, construction .....XXI (03) 353

Element, liquid, definition .....	XIX (02)	310
Elevated railways (see Railways).		
Elevator, acceleration relation to economy.....	XIX (02)	461
electric. a. c., advantages of induction motor....	XIX (02)	470
choice of motor.....	XIX (02)	460
induction motors .....	XIX (02)	454
power-factor .....	XIX (02)	432
power-time curves, tests.....	XIX (02)	431
vs. d. c. motors.....	XIX (02)	476
energy consumption .....	XIX (02)	466
motors, efficiency .....	XIX (02)	482
energy consumption.....	XIX (02)	478, 482
number of direct and alternat-		
ing-current, in New York....	XIX (02)	429
counter-balance, determination .....	XIX (02)	474
department store service, acceleration.....	XIX (02)	484
speeds .....	XIX (02)	484
economy relation to acceleration.....	XIX (02)	461
electric-hydraulic, energy consumption.....	XIX (02)	466
service, load curve .....	XIX (02)	456
E. m. f., contact, electronic theory.....	XXVI (07)	956
nature .....	XIX (02)	343
control (see Control).		
measurement, high values .....	XXIV (05)	421
difficulties .....	XXIII (04)	168
instrument transformer, advan-		
tages .....	XXIV (05)	445
instrument transformer, method,		
limitations .....	XXIV (05)	422
needle-gap .....	XXV (06)	373
accuracy .....	XXIV (05)	446
series condenser method, limita-		
tions .....	XXIV (05)	424
spark-gap method, limitations....	XXIV (05)	424;
xxvii (08) 1525		
tests .....	XIX (02)	267
step-up transformer method, limi-		
tations .....	XXIV (05)	421
voltmeter-multiplier method, limi-		
tations .....	XXIV (05)	424
meters (see Voltmeters).		
wave tracer, description .....	XIX (02)	1123
Owens type, advantages.....	XIX (02)	1125
Emplacement, definition .....	XIX (02)	665
Energy conservation (see Conservation).		
consumption, cars, effect of air brakes.....	XX (02)	280
elevator, electric .....	XIX (02)	466
electric-hydraulic .....	XIX (02)	466
induction motor .....	XIX (02)	478
motors, railway, concatenated-induc-		
tion .....	XIX (02)	538
d. c. series .....	XIX (02)	538
induction .....	XIX (02)	538
railway, electric, per passenger.....	XIX (02)	848
steam, per passenger.....	XIX (02)	848
train, electric, different schedule		
speeds .....	XIX (02)	828

Energy (*continued*)

- control (see Control).
- cost, production, hydroelectric plants.....xxviii (09) 1486
- ratio of fuel to total.....xxii (03) 503
- diagrams for roll pass.....xxix (10) 1388
- dielectric, conversion into chemical action.....xxvi (07) 1022
- effect on design of graded cables.....xxix (10) 1605
- disruptive discharge, estimation.....xxix (10) 1149
- electric, cost, analysis.....xxviii (09) 63, 1479
  - effect of load-factor..xxii (03) 780; xxv (06) 140
  - load curve .....xxviii (09) 1489
  - estimation .....xxix (10) 116
  - gas engine plants.....xxviii (09) 1484
  - steam-turbine plants...xxviii (09) 1485
  - Germany .....xxv (06) 38
  - Manhattan Elevated Ry. ....xxix (10) 1487
  - steam plants.....xxv (06) 187; xxix (10) 117
  - steam-engine plants .....xxviii (09) 1481
  - exhaust-turbine plants.xxviii (09) 1483
  - steam-turbine plants .....xxviii (09) 1482
  - variation with load-factor.....xxvi (07) 1762
- economy incident to centralized produc-
  - tion .....xxix (10) 110
  - generating cost relation to selling price...xxix (10) 342
  - price at Niagara Falls.....xix (02) 281
  - production cost, analysis.....xxviii (09) 63
  - economy, analysis .....xxviii (09) 68
  - storage as heat .....xxvii (08) 1600
  - transmitted, cost calculation.....xxviii (04) 769
- hydroelectric, prices in New England.....xxix (10) 123
- lagging, definition .....xxviii (09) 616
- leading, definition .....xxviii (09) 616
- measurement (see Measurement).
- meters (see Meters, watt-hour).
- radiation, distribution with temperature and wave
  - length .....xxix (10) 1721
- saving in rapid transit systems by grades to
  - stations .....xxix (10) 1492
- steam at different pressures.....xxv (06) 29
- surges .....xxvi (07) 419
- train acceleration equation .....xxii (03) 148
- Engen-Langen, suspended monorail railway, description..xviii (01) 55
- Engines, angular deviation, measurement.....xviii (01) 720, 777, 785
- binary, description .....xviii (01) 92
- performance tests .....xxi (03) 468
- connecting-rod, kinematical equation.....xviii (01) 709
  - moment of inertia about its
    - center .....xviii (01) 704
    - turning moment equation..xviii (01) 706, 710
  - crank pin, reaction equation.....xviii (01) 710
  - gas, back-fire, cause.....xxix (10) 437
  - Charlotte Electric Ry. plant, description...xxix (10) 428
  - cooling systems for large units.....xxix (10) 434
  - water, consumption .....xxii (03) 795;
    - xxvii (08) 1128
  - large units.....xxix (10) 433
- cost .....xxix (10) 690
- Europe .....xxv (06) 52

Engines, gas, (*continued*)

standby service plant.....	xxix	(10)	679
cylinder oil consumption.....	xxvii	(08)	1128
design for parallel operation.....	xxviii	(09)	147
double-acting, mode of operation.....	xxix	(10)	435
economical load range.....	xxv	(06)	46
economy characteristic .....	xxv	(06)	32
effect of superheat.....	xxiv	(05)	38
large sizes .....	xxix	(10)	245
efficiency .....	xviii	(01)	78
factors that affect.....	xxv	(06)	33
fuel, cost, actual.....	xxii	(03)	777
four-cycle, indicator card, typical.....	xxix	(10)	438
regulation methods .....	xxvi	(07)	17
valve diagram .....	xxix	(10)	440
governors, functions .....	xxvi	(07)	5
jacket water required.....	xxii	(03)	795
Körting, description .....	xviii	(01)	85
load-gas curve, 400 h.p. unit.....	xxv	(06)	22
losses, analysis .....	xxv	(06)	21
lubrication, bearings .....	xxix	(10)	433
maintenance charges .....	xxix	(10)	239
muffler explosions, cause.....	xxix	(10)	437
natural frequency, measurement.....	xxviii	(09)	148
Oechelheuser, description .....	xviii	(01)	88
operation, cost .....	xxii	(03)	779
actual .....	xxix	(10)	445
overload capacity .....	xxvii	(08)	1137
parallel operation.....	xxviii (09)	161; xxix	(10) 444
performance characteristics .....	xxii	(03)	773
piston packing, large units.....	xxix	(10)	432, 462
plants (see Power plants).			
producer plant fuel consumption, actual....	xxix	(10)	446
regulation problems .....	xxvi	(07)	1
specifications in Europe.....	xxv	(06)	51
size limit .....	xxix	(10)	690
specific consumption .....	xxv	(06)	51
400 h.p., at different			
loads .....	xxv	(06)	22
load characteristics....	xxv	(06)	53
speed variation, actual.....	xxix	(10)	444
standby charges .....	xxix	(10)	681
service, general specifications.....	xxix	(10)	676
operation, cost.....	xxix	(10)	683
thermal efficiency .....	xxix	(10)	686
time to start.....	xxix	(10)	680
valve gear, functions.....	xxvi	(07)	4
parallel operation (see Parallel operation).			
service tests .....	xxii	(03)	475
steam, angular deviation, measurement.....	xviii	(01)	777
displacement permitted for			
parallel operation.....	xviii	(01)	760
anti-surge device for governor.....	xviii	(01)	750
compound condensing, steam consump-			
tion .....	xxi	(03)	442
load-steam curve, unequal			
distribution .....	xxv	(06)	15

Engines, steam, (*continued*)

Corliss compound, steam consumption.....XXI	(03)	410
horizontal, floor space.....XXVII	(08)	1102
vertical, floor space.....XXVII	(08)	1102
crank effort, causes of irregularity.....XVIII	(01)	760
economical load range.....XXV	(06)	46
efficiency .....	XVIII (01)	78
governors, functions .....	XXVI (07)	5
horizontal, friction tests.....XXII	(03)	495
load-steam curve, 3,500 h. p. unit.....XXV	(06)	15
operation, cost .....	XXII (03)	779
parallel operation (see Parallel operation).		
perfect, steam consumption, theoretical.....XXVI	(07)	1753
plants (see Power plants).		
space requirements .....	XXI (03)	411
specific consumption, 3,500 h. p., at differ-		
ent loads.....XXV	(06)	15
load characteristics.....XXV	(06)	53
saving due to		
vacuum .....	XXV (06)	16
stops, automatic .....	XXV (06)	635
Sulzer, steam consumption.....XXI	(03)	442
tandem compound, angular variation		
tests .....	XVIII (01)	725
testing, vacuum, precision measurement.....XXIX	(10)	1706
weighing tanks, construction.....XXIX	(10)	1701
unbalanced forces .....	XVIII (01)	768
valve gear, functions.....XXVI	(07)	4
with exhaust-turbine, 15,000-kw., plan and		
elevation .....	XXIX (10)	226
with exhaust-turbine, effect of super-		
heat on economy.....XXIX	(10)	246
with exhaust-turbine plant, operation		
cost, actual .....	XXVI (07)	1761
with exhaust-turbine, specific consump-		
tion .....	XXV (06)	23
with exhaust-turbine, temperature-entropy		
diagram .....	XXVI (07)	1756
with exhaust-turbine, testing layout.....XXIX	(10)	221
tests .....	XXIX (10)	190
stops, automatic .....	XXV (06)	635
methods of applying.....XXV	(06)	637
testing .....	XXV (06)	640
sulphur dioxide, description.....XVIII	(01)	92
mode of operation.....XVIII	(01)	95
performance, tests .....	XVIII (01)	96
testing logs .....	XXII (03)	477
turning moment of connecting rod, equation.....XVIII	(01)	706
due to inertia of reciprocating		
parts .....	XVIII (01)	708
steam force.....XVIII	(01)	708
waste heat, performance tests.....XXI	(03)	468
Engineers, activity in public affairs.....XXVII	(08)	335
definition .....	XXII (03)	3
duties in public life.....XXVII	(08)	459
electrical, education (see Education).		
importance .....	XXIX (10)	650

**Engineers, electrical, (*continued*)**

position in public life.....	xxviii (09)	1107
relation to industrial, commercial and social life.....	xx (02)	6
importance in commercial affairs.....	xxvii (08)	340
limitations of average.....	xxvii (08)	337
manufacturing, education .....	xxii (03)	590
moral duties .....	xxv (06)	243
notable, ages .....	xxix (10)	654
qualifications for success.....	xxii (03)	574
telephone, functions .....	xxi (03)	81
relations to telephone organizations.....	xxv (06)	103
traffic, functions .....	xxv (06)	109
<b>Engineering, definition.....</b>	xxiv (05) 284; xxvii (08)	459
electrical, commercial aspect.....	xix (02)	1159
typical courses of study.....	xxii (03)	605
English .....	xxii (03)	609
ethics .....	xxv (06)	241
honor .....	xxv (06)	241
societies, foreign, magnitude of member- ship .....	xxiv (05)	285
membership classifica- tion .....	xxiv (05)	285
national, magnitude of member- ship .....	xxiv (05)	285
membership classifica- tion .....	xxiv (05)	285
Societies Building, resolutions.....	xxi (03)	487
society, first .....	xxiv (05)	283
specialization, cause .....	xxvii (08)	459
English, examples of poor.....	xxii (03)	609
<b>Entries, high-tension, construction.....</b>	xxiii (04)	578
15,000 volts .....	xxii (03)	315
30,000 volts.....	xxii (03)	316, 320
40,000 volts.....	xxii (03)	322, 326
50,000 volts.....	xxii (03)	323, 326
design .....	xxii (03)	319
general requirements .....	xxii (03)	314
Missouri River Power Co.....	xxii (03)	322
protection from weather.....	xxii (03)	319, 327
roof insulator, construction, 50,000- volt .....	xxii (03)	325
Snoqualmie Power Co.....	xxii (03)	321
Epstein core loss tester vs. Lloyd apparatus.....	xxviii (09)	468
Equalization efficiency, definition .....	xxii (03)	253
Equipotential surfaces, calculation.....	xxviii (09)	771
Equivalent needle-gap (see Needle-gap).....	xxvii (08)	285
Erie steering gear, canal boats.....	xxvii (08)	288
diagram .....	xxv (06)	266
<b>Ethics, code, committee nomination.....</b>	xxv (06)	253
proposed for electrical engineers.....	xxv (07)	1421
of architecture .....	xxv (06)	254
engineering .....	xxv (06)	248
law .....	xxv (06)	249
medicine .....	xxiv (05)	866
<b>Exciter, a. c., design for 5 cycles.....</b>	xxiv (05)	871
low-frequency, e. m. f. characteristics.....	xxvii (08)	1454
cost calculation .....		

- Exciter, (*continued*)  
     rating as per cent. of generator.....XXVIII (09) 979  
     synchronous, advantages in a. c. regulation.....XXVII (08) 1015  
         for split-pole converter.....XXVII (08) 1012  
         for split-pole converter, character-  
             istics .....XXVIII (09) 867  
         for split-pole converter, theory....XXVIII (09) 854
- Factories, advantages in buying electric energy.....XXIX (10) 126, 132  
     induction motor, requirements.....XXIX (10) 147  
     lighting (see Lighting).
- Faraday's law of electromagnetic induction.....XXVII (08) 1341
- Farm products, value in Central States.....XXIV (05) 1075
- Farnsworth train lighting system.....XXI (03) 164
- Feed water heater, saving with exhaust steam.....XXIV (05) 46  
     temperature variation, record at Philadelphia.XXIX (10) 348
- Feeder, a. c., drop compensator.....XXVII (08) 272  
     starting with synchronous motor and Tirrill  
         regulator .....XXVII (08) 274  
     control (see Control).  
     losses in central station plant.....XXVI (07) 678  
     railway, 1,200 and 600-volt d. c., requirements...XXIX (10) 8  
         equivalent copper of substation.....XXIX (10) 5  
         return, design for reducing stray cur-  
             rents to a minimum.....XXVI (07) 247  
     regulator, relative merits of different types.....XXVII (08) 255
- Ferraris power-factor meter, mode of operation.....XXVIII (01) 299
- Fessenden hot-wire barretter, characteristics.....XXV (06) 784  
     liquid barretter, characteristics.....XXV (06) 785  
     wireless telephone system, description.....XXVII (08) 603
- Fiber conduit, dielectric strength.....XXV (06) 866  
     insulation resistance, effect of moisture...XXV (06) 869
- Field coils (see Coils).  
     electric, about grounded wires.....XXVI (07) 875  
         transmission line .....XXIII (04) 660  
         towers .....XXVI (07) 880  
         equipotential surfaces, calculation.....XXVIII (09) 771  
         physical conception .....XXIII (04) 106  
     magnetic, about transmission line.....XXIII (04) 660  
     rotating, characteristics .....XXVII (08) 1380
- Field-poles alternators, typical.....XXIII (04) 283  
     construction, Niagara generator No. 1.....XXVIII (01) 467  
     face losses calculation, laminated shoes....XXVIII (09) 1143  
         solid shoes.....XXVIII (09) 1139  
         due to reluctance pulsation....XXVIII (09) 1137  
         observed, laminated shoes.....XXVIII (09) 1145  
         solid shoes.....XXVIII (09) 1145  
         theory .....XXVIII (09) 1133  
     laminations, thickness .....XXIII (04) 263  
     shoes, effect of lamination.....XXVIII (09) 1153
- Field-rings, permeability measurement.....XXVIII (01) 464
- Field-winding (see Winding).
- Filaments, carbon, color compensation of light.....XXIX (10) 1726  
     energy distribution with wave length..XXIX (10) 1724  
     resistance .....XXIX (10) 931  
     resistance-temperature characteristics..XXIV (05) 841  
     temperature limit .....XXV (06) 791



Filaments, ( <i>continued</i> )		
graphitized, resistance .....	XXIX (10)	930
resistance-temperature character- istics .....	XXIV (05)	841, 845
resistance-temperature character- istics, different firing tem- peratures .....	XXIV (05)	842
specific consumption .....	XXIV (05)	847
incandescent, intrinsic brilliancy .....	XXVI (07)	628
osmium, diameter .....	XXV (06)	819
energy distribution with wave length .....	XXIX (10)	1724
resistance .....	XXIX (10)	930
stresses, analysis .....	XXIX (10)	947
tantalum, diameter .....	XXV (06)	819
effect of alternating current .....	XXV (06)	829
resistance .....	XXIX (10)	930
tungsten, color composition of light .....	XXIX (10)	1726
cooling curves .....	XXIX (10)	946, 1720
critical flicker frequency .....	XXIX (10)	1728
diameter .....	XXV (06)	819
diamond dies .....	XXIX (10)	1711
disintegration with use .....	XXIX (10)	949
energy distribution, wave length .....	XXIX (10)	1724
Just & Hanaman process .....	XXV (06)	817
Kuzel's process .....	XXV (06)	817
length .....	XXIX (10)	931
manufacture, methods .....	XXIX (10)	1710
overshooting .....	XXIX (10)	941
performance characteristics .....	XXIX (10)	1714
resistance .....	XXIX (10)	931
stresses, analysis .....	XXIX (10)	947
temperature acceleration .....	XXIX (10)	942
Finsen light treatments .....	XXI (03)	399
telescope .....	XXI (03)	399
Fire extinguisher, transformer oil .....	XXIII (04)	179
hazard of electricity .....	XXVII (08)	471
loss in U. S. ....	XXVII (08)	467
oil, steam as an extinguisher .....	XXIII (04)	188
transformers, experience .....	XXIII (04)	193, 195
protection engineer, duties .....	XXVII (08)	470
risk, air-blast transformers, method of reducing .....	XXIII (04)	194
dust .....	XXIII (04)	175
effect of skilled operators .....	XXIII (04)	185
oil transformers .....	XXIII (04)	176
Snoqualmie Falls, account .....	XXIII (04)	180
Fire-proofing compound, formula .....	XXVII (08)	781
Flame, acetylene, luminous intensity .....	XIX (02)	53
spectrophotometric measurements .....	XIX (02)	54
electric conduction .....	XXV (06)	738
Flash-boiler, electric, construction .....	XXVII (08)	667
evaporative efficiency .....	XXVII (08)	664
Fleming rectifier (see Rectifier) .....		
Flicker, critical frequency for Nernst lamps .....	XVIII (01)	584
method of overcoming .....	XX (02)	26
tungsten lamps on low frequency .....	XXIX (10)	934
Floors, concrete, construction .....	XXIV (05)	57
Flue gas analyzer, description .....	XXVI (07)	1773
Flume velocities, standard .....	XXV (06)	153

Fluorescence, definition .....	XXI (03)	331
Fluorescent screens, composition.....	XXI (03)	333
substances .....	XXI (03)	332
Flux densities, generators, a. c., air-gap.....	XXII (03)	56
acyclic .....	XXIV (05)	26
motor, Heyland .....	XXI (03)	555
induction, selection .....	XXIV (05)	677
dielectric, at different distances from line.....	XXIII (04)	123
parallel conductors, formula.....	XXIII (04)	111
Flywheels, calculation .....	XXVIII (09)	871, 932
equation .....	XXIII (04)	360
for parallel operation.....	XVIII (01)	763, 772
cast-iron, maximum peripheral speed.....	XXIII (04)	274
cast steel, maximum peripheral speed.....	XXIII (04)	274
effect of percentage of motor compounding		
upon performance.....	XXVII (08)	331
on calculation, parallel generators.....	XVIII (01)	798
engine governor .....	XXIII (04)	357
synchronous apparatus.....	XXIII (04)	359
elastic stresses, theory.....	XXVII (08)	1059
energy efficiency .....	XXIX (10)	1386
functions in rolling mills, analysis.....	XXVIII (09)	869
laminated, maximum peripheral speed.....	XXIII (04)	274
light, advantages .....	XXIII (04)	362
rolling mills, selection for given service.....	XXVIII (09)	874
use with bloom shears.....	XXVII (08)	322
Flywheel-effect, synchronous motors.....	XXIII (04)	508
Fog, effect on high tension insulator performance.....	XXIX (10)	718
Foote & Randall chemical automatic telegraph.....	XXIX (10)	1309
Footings for transmission towers, cost.....	XXVI (07)	1236
metal, for transmission towers, holding-down		
power, tests .....	XXVI (07)	1316
Forced oil cooling (see Cooling).		
Forests, action in stream preservation.....	XXIV (05)	891
as national asset .....	XXVII (08)	487
reserves, primary object.....	XXVIII (09)	180
Form-factor, correction .....	XXVIII (09)	426
definition .....	XXVIII (09)	432
Fort, definition .....	XIX (02)	665
Fort Wayne double-deck turbine station.....	XXVII (08)	1113
Foundations for transmission towers, cost.....	XXVI (07)	1236
Fourth rail London underground roads.....	XXVII (08)	1215
Franchises for natural resources, perpetual vs. limited ..	XXVII (08)	495, 498
valuation, examples of present practice.....	XXVII (08)	347
logical method .....	XXVII (08)	350
Franklin a. c. series motor with external armature.....	XXIX (10)	32
Freight business, in rural districts Central States, estimate.....	XXIV (05)	1075
value of farm products in Central States .....	XXIV (05)	1075
haulage as night load for hydroelectric plants.....	XXIX (10)	567
Frequency, 25 cycles, reasons for adoption at Niagara		
Falls .....	XXVIII (01)	451
audible range .....	XXVIII (09)	1186
measurement with stroboscopic fork.....	XXVII (08)	645
meter for very high frequencies, description.....	XXVII (08)	684
Lincoln, description .....	XXVIII (01)	262
theory .....	XXVIII (01)	264
natural, gas engines.....	XXVIII (09)	148

Friction air, high-speed machinery.....	XXVIII	(09)	406
coefficient, iron-tired wheels.....	XX	(02)	245
steel and steel .....	XXIV	(05)	609
tired wheels .....	XX	(02)	245
sliding, coefficient, variation with distance.....	XX	(02)	241
speed.....	XX	(02)	239
torque, mine hoists, calculation.....	XXIX	(10)	296
Friese water resistor, static discharger.....	XXIV	(05)	948
Fuels (see name of Fuel).			
consumption, railway power plant.....	XXII	(03)	492, 498
contracts on B. t. u. basis.....	XXVIII	(09)	51
cost in Germany .....	XXV	(06)	51
purchase on B. t. u. basis.....	XXVIII	(09)	51
Furnace, electric, electrodes (see Electrodes).			
losses, Hering's laws....	XXIX	(10)	465, 492
investigation, experi-			
mental .....	XXIX	(10)	485
investigation, theo-			
retical .....	XXIX	(10)	465
temperature distribution.....	XXIX	(10)	476
maximum			
possible.....	XIX	(02)	296
maximum			
practicable....	XIX	(02)	297
Fuses, 16,000-volt, outdoor, description.....	XXVI	(07)	1295
50,000-volt, description .....	XXVII	(08)	844
aluminium, experience, Niagara Falls Power Co....	XXVIII	(01)	496
application to circuit breakers on transmission			
lines .....	XVIII	(01)	497
design .....	XXVIII	(09)	947
early types .....	XXVIII	(09)	971
enclosed, accuracy .....	XXVIII	(09)	974
compared with open link.....	XXVIII	(09)	947
expansive action, causes.....	XXVIII	(09)	967
filling, function .....	XXVIII	(09)	972
heat dissipation, calculation.....	XXVIII	(09)	950
moisture content .....	XXVIII	(09)	973
performance, actual .....	XXVIII	(09)	954
theory .....	XXVIII	(09)	948
Underwriters' tests .....	XXIV	(05)	904
energy dissipation, determination.....	XXVIII	(09)	970
high-tension, tests .....	XXV	(06)	358
waterproof .....	XXVIII	(09)	255
multiple-link vs. single.....	XXVIII	(09)	965
N. E. Code standard, specifications.....	XXIV	(05)	908
open-link, compared with enclosed.....	XXVIII	(09)	947
objections .....	XXIV	(05)	893
potential rise, cause.....	XXIV	(05)	916
power of short-circuits.....	XXIX	(10)	1117
single-link vs. multiple.....	XXVIII	(09)	965
telephone protection from high-tension, tests.....	XXV	(06)	358
Galvanizing, tests for quality.....	XIX	(02)	695
Gary Plant, electric power station.....	XXVIII	(09)	108
electrical equipment .....	XXVIII	(09)	101
ore handling equipment.....	XXVIII	(09)	118
power requirements of various machines.....	XXVIII	(09)	115
storage battery, description.....	XXVII	(08)	995; XXVIII
equipment .....	XXVIII	(09)	851
			110

- Gas and electric plant, financial analysis.....XXII (03) 783
- Gas-engine (see Engine).  
     bearings, lubrication .....XXIX (10) 433  
     plant (see Power plants).
- Gases, blast furnace, excess over that required for steel  
     making .....XXVIII (09) 156  
     quantity per unit output.....XXVIII (01) 81  
     thermal value .....XXII (03) 775  
     utilization in engines.....XXVIII (01) 81  
         Germany.....XXV (06) 37
- carburetted-water, thermal value.....XXII (03) 775
- coal, cost of production.....XXII (03) 782  
     thermal value .....XXII (03) 775
- coke oven, thermal value.....XXII (03) 775
- luminescence, theory .....XXV (06) 796
- luminescent characteristics, corpuscular theory....XXV (06) 851
- mixed, cost of production.....XXII (03) 782
- natural, thermal value.....XXII (03) 775
- producer, theory of manufacture.....XXIX (10) 452
- storage, cost .....XXII (03) 771
- tunnel, electric protection.....XXIX (10) 371
- water, cost of production.....XXII (03) 782  
     thermal value .....XXII (03) 775
- Gas-pipe grounds (see Ground pipes).
- Gas-plant, cost of operation.....XXII (03) 788  
     revenue .....XXII (03) 788  
     with electric auxiliary, financial analysis.....XXII (03) 788
- Gas-processes, thermal efficiency of various.....XXII (03) 776
- Gas-producer, advantage of large gas holder.....XXIX (10) 450  
     down-draft type, mode of operation.....XXIX (10) 447  
     economy, effect of load-factor.....XXV (06) 58  
     fuel consumption, actual.....XXIX (10) 446  
     losses, analysis .....XXV (06) 21  
     standby losses .....XXVII (08) 1127  
     thermal efficiency of various.....XXII (03) 776
- Gears, life of railway pinions.....XXIX (10) 1434  
     ratios, railway practice.....XXIV (05) 569  
     teeth, allowable pressure.....XXIX (10) 1434  
     transmission for electric locomotives.....XXIX (10) 1432
- Gem lamps (see Lamps, incandescent, graphitized).
- General Electric apprenticeship course, description.....XXVII (08) 1462
- Generating unit, high-speed output per unit weight.....XIX (02) 588
- Generator, a. c., 10,000-h. p., 12,000-volt, construction.....XXVII (08) 1058  
     electric charac-  
         teristics.....XXVII (08) 1064
- air-gap densities .....XXII (03) 56
- ampere-turns per pole.....XXII (03) 56
- angular displacement, standard specifica-  
     tion .....XXIII (04) 353  
     velocity variation, standard.....XXIII (04) 272
- armature, copper, cost.....XXVII (08) 1439  
     weight .....XXVII (08) 1439  
     iron, cost .....XXVII (08) 1441  
     weight .....XXVII (08) 1441
- laminations, support .....XXIII (04) 262
- reaction (see Armature reaction).
- windings, classification.....XXVIII (09) 1054

Generator, a. c., (*continued*)

Behrend heat test.....	XXV (06)	311
belt-driven, speed-output curve.....	XXIII (04)	256
Brown, low-speed, general design.....	XXII (03)	40
characteristics, determination .....	XIX (02)	1093
circle diagram of parallel operation.....	XXVI (07)	1028
collector rings, mechanical construction, typical .....	XXIII (04)	286
compounding, Baum compensator, tests.....	XIX (02)	802
for load variations.....	XIX (02)	746
power-factor variations.....	XIX (02)	746
necessity .....	XIX (02)	745
compromise heat test.....	XXV (06)	326
cost armature copper with rating.....	XXVIII (09)	980
iron with rating.....	XXVIII (09)	981
calculation .....	XXVII (08)	1429
comparison 25 and 60 cycles.....	XXVIII (09)	975
field copper with rating.....	XXVIII (09)	980
iron with rating.....	XXVIII (09)	981
iron and copper with rating.....	XXVIII (09)	985
relative, 25 and 60 cycles.....	XXVIII (09)	988
100 and 300 rev. per min.....	XXVIII (09)	988
cost-speed, characteristic .....	XXV (06)	159
demagnetizing m. m. f. calculation, gen- eral equation .....	XXIII (04)	300
demagnetizing m. m. f., distributed single- phase winding .....	XXIII (04)	299
demagnetizing m. m. f. with single-slot, single-phase winding .....	XXIII (04)	298
design, development, history.....	XXIII (04)	253
use of short-circuit, character- istic .....	XXI (03)	515
dimensions and weight, 850-kw. three- phase .....	XXIII (04)	315
distorting m. m. f. calculation, general equation .....	XXIII (04)	300
distorting m. m. f. distributed single-phase winding .....	XXIII (04)	299
distorting m. m. f. with single-slot, single- phase winding .....	XXIII (04)	298
efficiency formula, parallel operation.....	XXVI (07)	1038
e. m. f. relation to power rating.....	XXV (06)	559
energy loss in insulation, tests.....	XIX (02)	1057
engine-driven, air-gaps .....	XXIII (04)	255
frame construction.....	XXIII (04)	260
speed-output curve.....	XXIII (04)	256
exciter cost, calculation.....	XXVII (08)	1454
rating, choice .....	XXVIII (09)	979
exciting current, calculation, Adams method .....	XXIII (04)	324
exciting current, calculation, comparison m. m. f., e. m. f. and Adams methods with tests .....	XXIII (04)	324
Ferranti, low-speed, general design.....	XXII (03)	42
field copper, cost.....	XXVII (08)	1436
weight .....	XXVII (08)	1436
Goldschmidt heat test.....	XXV (06)	317

Generator, a. c., (*continued*)

half-frequency for high-speed low frequency service .....	xxvi (07)	1394
harmonics, elimination in design.....	xxviii (09)	1063
heat test .....	xxv (06)	326
analysis, various methods.....	xxv (06)	311
connections for various.....	xxv (06)	318
Heyland, advantages .....	xxi (03)	567
compound, circuit diagram.....	xxi (03)	558
disadvantages .....	xxi (03)	567
excitation characteristics.....	xxi (03)	557, 561
performance characteristics.....	xxi (03)	551
high-frequency, air friction.....	xxviii (09)	406
characteristics, 100,000-cycle .....	xxviii (09)	409
description, 100,000-cycle.....	xxviii (09)	400
early type.....	xxviii (09)	400
heating, 100,000-cycle.....	xxviii (09)	414
lamination thickness.....	xxiii (04)	418
Leblanc, armature construction .....	xxiii (04)	419
Leblanc, description.....	xxiii (04)	417
Leblanc, field construction .....	xxiii (04)	421
Leblanc, iron loss tests at various frequencies .....	xxiii (04)	423
Leblanc, regulation tests.....	xxiii (04)	426
Leblanc, saturation curves at various frequencies .....	xxiii (04)	422
Leblanc, short-circuit currents at different frequencies.....	xxiii (04)	425
Leblanc, windage and friction losses.....	xxiii (04)	425
maximum permissible, number of poles.....	xxiii (04)	418
regulation, 100,000-cycle.....	xxviii (09)	408
wireless work, first built .....	xxvii (08)	567
high-tension 40,000-volt .....	xxvi (07)	380
cost compared with medium tension .....	xxvi (07)	367, 369
data 20,000-volt.....	xxvi (07)	376
design, mechanical difficulties .....	xxvi (07)	353
early types .....	xxvi (07)	362
efficiency compared with medium tension.....	xxvi (07)	367
heating characteristics, 22,000-volt .....	xxvi (07)	355
losses compared with low-tension .....	xxvi (07)	352
operation difficulties.....	xxvi (07)	359
regulation characteristics, 22,000-volt .....	xxvi (07)	354
repairs .....	xxvi (07)	357

Generator, a. c., (*continued*)

hub-sections, typical .....	xxiii (04)	268
hunting, cause .....	xviii (01)	757
effect of weight of flywheel.....	xxiii (04)	354
remedy .....	xviii (01)	757
inductance, effect of slot shape.....	xxiii (04)	269
induction, 11,000-volt 25 cycle, descrip- tion .....	xxix (10)	187
advantages .....	xxvii (08)	237
long distance transmission.....	xxviii (09)	631
aggregate of small water powers .....	xxvii (08)	240
air-gap size .....	xxvii (08)	249
central station work.....	xxvii (08)	157
characteristic performance.....	xxix (10)	240
effect on line disturbances.....	xxvii (08)	169
excitation .....	xxvii (08)	165
excitation, a. c., exciting cur- rent determination.....	xxiv (05)	861
excitation, a. c., mode of operation .....	xxiv (05)	873
excitation, a. c., performance.....	xxiv (05)	851
excitation, a. c., regulation.....	xxiv (05)	858
gas-engine driven, perform- ance characteristics.....	xxvii (08)	163
inventor .....	xxvii (08)	236
method of starting.....	xxix (10)	187
parallel with synchronous generator, regulation.....	xxix (10)	241
performance characteristics.....	xxvii (08)	159
power station work, advan- tages .....	xxvii (08)	232
power station work, disad- vantages .....	xxvii (08)	234
self-excitation .....	xxvii (08)	239
steam-turbine driven, per- formance characteristics.....	xxvii (08)	163
with synchronous converter, combined efficiency.....	xxvii (08)	178
with synchronous converter, compared with d. c. gene- rator.....	xxvii (08)	178, 180
with synchronous converter, steam consumption.....	xxvii (08)	180
inductor type, flux distribution.....	xix (02)	1095
regulation, determination....	xix (02)	1115
instrument equipment, New York Edison Co. ....	xxii (03)	431
laminations, thickness .....	xxiii (04)	263
Latour self-exciting .....	xxi (03)	569
method of com- pounding .....	xxi (03)	569
leakage, effect of design factors.....	xxii (03)	51
low-speed armature, current density.....	xxii (03)	47
best ratio of pole face to pole pitch .....	xxii (03)	47
general design .....	xxii (03)	40, 42

Generator, a. c., low-speed (*continued*)

leakage coefficients.....XXII	(03)	52
magnetic circuits, for armature flux.....XXIII	(04)	292
flux distribution, effect of armature m. m. f. ....XXIII	(04)	295
material scrapped, estimate.....XXVIII	(09)	978
mechanically coupled and electrically in series .....	XVIII	(01) 795
Niagara Falls No. 1 collector rings.....XVIII	(01)	469
field ring, manufacture .....	XVIII	(01) 464
field ring, physical characteristics .....	XVIII	(01) 463
losses and efficiency..XVIII	(01)	476
mechanical features..XVIII	(01)	459
revolving weight.....XVIII	(01)	462
short-circuit stresses, magnitude .....	XVIII	(01) 487
spider, physical properties .....	XVIII	(01) 469
temperatures .....	XVIII	(01) 477
temperature distribution, measurement .....	XVIII	(01) 482
wave-form .....	XVIII	(01) 474
parallel operation (see Parallel operation).		
peripheral speed, maximum.....XXIII	(04)	274
pole pitch and frequency, relations.....XXIII	(04)	284
pole material, cost.....XXVII	(08)	1444
weight.....XXVII	(08)	1444
pole-pitch, relation to peripheral speed and frequency .....	XXIII	(04) 284
power input, equation for parallel operation .....	XXVI	(07) 1035
output, equation for parallel operation .....	XXVI	(07) 1034
protection .....	XXIV	(05) 248
regulation, calculation .....	XXIII	(04) 327
Adams method....XXIII	(04)	324
comparison m.m.f., e. m.f. and Adams methods with tests .....	XXIII	(04) 324
graphical method..XXIII	(04)	330
indirect method.....XIX	(02)	1109
zero power-factor..XXIII	(04)	310
determination from short-circuit characteristic.....XIX	(02)	1111
determination, two-reactance method .....	XIX	(02) 1113
effect of various design factors .....	XXII	(03) 478
importance of specifying.....XXI	(03)	579
Kapp diagram .....	XXI	(03) 581
relation to switch rating.....XXV	(06)	560
relative proportions of copper and iron.....XXVII	(08)	1429



Generator, a. c., (*continued*)

requirements for parallel operation.....	xviii (01)	775
revolving field, vertical shaft, balancing, method .....	xviii (01)	471
rim-arms, typical .....	xxiii (04)	268
self-exciting compounding, description.....	xxv (06)	61
design, principles .....	xxv (06)	62
self-synchronizing .....	xxv (06)	453
series operation of mechanically coupled.....	xviii (01)	795
short circuit characteristic, use in design.....	xxi (03)	515
single-phase cost compared with three- phase .....	xxiii (04)	97
disadvantages .....	xxvi (07)	1367
heating .....	xxv (06)	313
in two-phase, relation.....	xix (02)	856
losses, calculation.....	xxvii (08)	1071
short-circuit test, New Haven road.....	xxvii (08)	1672
slot profiles, typical.....	xxiii (04)	263
speed cost, characteristic.....	xxv (06)	159
peripheral, relation to pole pitch and frequency.....	xxiii (04)	284
split-armature, heat test.....	xxv (06)	318
split-field, heat test.....	xxv (06)	318
star-connected, advantages on transmis- sion line .....	xxvi (07)	1635
star-connected, cross-currents with grounded neutral, oscillogram.....	xxvi (07)	1608
star-connected, effect on harmonies.....	xxv (06)	704
star-connected, measurement of triple harmonies in neutral.....	xxix (10)	781
star-connected, method of connecting to grounded neutral system.....	xxix (10)	805
star-connected, operated with graded resistance lightning arresters.....	xxvi (07)	1150
star-connected, parallel operation with neutrals interconnected .....	xxix (10)	765
synchronizing, power formula.....	xxvi (07)	1043
three-phase, cost compared with single- phase .....	xxiii (04)	97
first .....	xxviii (09)	8
on single-phase circuit.....	xviii (01)	806
on single-phase load, cor- rection for unbalance.....	xxvi (07)	1373
single-phase rating.....	xviii (01)	807
turbo, construction details.....	xxiii (04)	276
dampers, construction .....	xxvii (08)	1089
effect on core losses.....	xxvii (08)	1090
description .....	xxvi (07)	1749
peripheral speed .....	xxii (03)	54
rotor, construction.....	xxvii (08)	1088
single-phase, effect of dampers on losses .....	xxvii (08)	1074
losses, calculation.....	xxvii (08)	1071
mechanical stress in end connections.....	xxvii (08)	1075
reactors to avoid pulsation .....	xxvii (08)	1092

- Generator, a. c., turbo, single-phase, (*continues*)
- short-circuit test....XXVII (08) 1672
  - speed-output curve.....XXIII (04) 257
  - three-phase, effect of dampers on losses .....XXVII (08) 1074
  - turbo-induction, 11,000-volt 25-cycle, de-  
scription... ..XXIX (10) 187
  - method of starting.....XXIX (10) 187
  - two-phase, advantage over three-phase..XVIII (01) 895
  - single-phase rating.....XVIII (01) 896
  - ventilating spaces, dimensions.....XXIII (04) 271
  - vertical, oil pressure in thrust bearing...XVIII (01) 476
  - shaft balancing, method.....XVIII (01) 471
  - ventilation .....XIX (02) 768
  - volume with rating.....XXVIII (09) 987
  - water turbine-driven, speed-output curve..XXIII (04) 256
  - wave-shape calculation .....XXVIII (09) 1053
  - examples .....XXVIII (09) 1069
  - weight and dimensions, 850 kw. three-  
phase .....XXIII (04) 315
  - copper and iron with rating.....XXVIII (09) 984
  - yoke material, cost.....XXVII (08) 1443
  - weight .....XXVII (08) 1443
  - typical sections .....XXIII (04) 254
- acyclic, advantages over alternating current...XXIV (05) 20
- air-gap .....XXIV (05) 27
  - armature reaction (see Armature reaction).
  - brush losses .....XXIV (05) 14
  - classification .....XXIV (05) 1
  - compounding .....XXIV (05) 10, 25
  - efficiency .....XXIV (05) 13
  - e. m. f. formula .....XXIV (05) 3
  - flux density .....XXIV (05) 26
  - friction losses .....XXIV (05) 14
  - I<sup>2</sup>R losses .....XXIV (05) 13
- angular displacement measurement.....XVIII (01) 719, 785
- arc, Brush characteristics.....XXVIII (09) 13, 32
- design data .....XXVIII (09) 30
  - regulation method .....XXVIII (09) 30
- Excelsior, regulation system.....XXVIII (09) 30
- instability .....XXVIII (09) 11
- internal resistance, early types.....XXVIII (09) 5
- Schuyler, regulation system.....XXVIII (09) 30
- Thomson-Houston, commutation.....XXVIII (09) 12
- design data... ..XXVIII (09) 8
- cost of different sizes.....XXVIII (09) 986
- d. c., adjustable reluctance, first patent.....XIX (02) 1132
- armatures, method of design.....XXIV (05) 702
  - commutation (see Commutation).
  - field strength control with adjustable  
reluctance .....XIX (02) 1131
  - limiting sizes .....XXIV (05) 709
  - actual .....XXIV (05) 713
  - railway, characteristics.....XVIII (01) 603, 604
  - self-excited, instability .....XXVIII (09) 2
  - short-circuit current, effect of commu-  
tating poles .....XXIX (10) 1641
  - three-wire, wiring diagram.....XX (02) 129

- Generator, (*continued*)  
 design, advantages of fractional pitch wind-  
   ings .....XXVII (08) 1077  
   development, history .....XXIII (04) 253  
   elastic stresses, theory.....XXVII (08) 1059  
 electric, first in U. S. ....XXVIII (09) 38  
 e. m. f., single-conductor, wave formula.....XXVII (08) 961  
 engine-driven unit, performance test.....XIX (02) 595  
   U. S. Navy specifications.....XIX (02) 590  
 field-poles (see Field-poles).  
 frame insulation for lightning protection.....XXVI (07) 372  
 gas-engine driven, parallel operation.....XXIX (10) 444  
 high-speed, air friction.....XXVIII (09) 406  
 insulation, graded .....XXIX (10) 1593  
 low-frequency (5-cycle), design.....XXIV (05) 866  
 plant, natural frequency of oscillation.....XXIII (04) 354  
 regulation, effect of charging line current.....XXII (03) 375  
 service tests .....XXII (03) 475  
 telegraph plants .....XXIX (10) 1313  
 unit, natural period of oscillation, equation.....XXIII (04) 360  
 U. S. Navy specifications.....XIX (02) 592  
 water-wheel, rating relation to wheel rating.....XXV (06) 159  
   ratings, standard .....XXV (06) 159  
   regulation, standard .....XXV (06) 159  
 Glass, French plate, reflection coefficient.....XVIII (01) 683  
   lead and potash, relative merits.....XXI (03) 312  
   performance under localized dielectric stress.....XXIX (10) 1591  
   smoked, method of smoking.....XVIII (01) 684  
 Globe, diffusing, spherical, formula for radius.....XIX (02) 10  
 Gloves, rubber, objection to use by linemen.....XXII (03) 760  
 Gola lightning arrester.....XXIV (05) 945  
 Gold, electrolytic separation process.....XIX (02) 285  
   electroplating, process .....XIX (02) 281  
 Goldschmidt heat test of alternators.....XXV (06) 317  
 Gornegrat three-phase railway, description.....XIX (02) 502  
 Goss-Mailloux train resistance formula.....XXIII (04) 731  
 Gould train-lighting system.....XXI (03) 208  
 Government control, water power.....XXVIII (09) 1435  
 Governors, engine, dash-pot to prevent surging.....XVIII (01) 750  
   effect of variation of flywheel effect.....XXIII (04) 357  
   functions .....XXVI (07) 5  
   requirements for parallel operation.....XXVIII (01) 773  
   speed, effect of friction on operation.....XXVI (07) 7  
   windage on operation.....XXVI (07) 7  
   water turbine, compensated.....XXV (06) 171  
 Graded insulation (see Insulation).  
 Graduates, engineering, criticisms.....XXII (03) 584  
 Grand Central Terminal, plan.....XIX (02) 866  
 Graphite, conductivity, electric, at high temperatures.....XXIX (10) 507  
   heat, at high temperatures.....XXIX (10) 507, 536  
   deflocculated .....XXVI (07) 1363  
   electrolytic production .....XIX (02) 290  
   resistivity, electric, at high temperatures.....XXIX (10) 507  
   heat, at high temperatures.....XXIX (10) 507, 536  
   temperature coefficient.....XXIX (10) 537  
 Gravel, resistivity, heat .....XXVI (07) 992  
 Gray, early writing telegraph, description.....XXIII (04) 646

- Great Northern Cascade Tunnel, power station.....xxviii (09) 1292  
 system, description.....xxviii (09) 1281  
 system, efficiency.....xxviii (09) 1313  
 system, locomotive, design and performance .....xxviii (09) 1284  
 system, overhead construction .....xxviii (09) 1301  
 system, overhead structure, description.....xxviii (09) 1337
- Grosse-Lichterfelde experimental railway, description...xviii (01) 108  
 three-phase railway, tests.....xix (02) 517
- Ground, arcing, detection with oscillograph.....xxvii (08) 1557  
 effect of series inductance.....xxvii (08) 749  
 resistance .....xxvii (08) 750  
 production for test purposes.....xxvii (08) 742
- cable on Guanajuato line.....xxvi (07) 1245
- connection for lightning arresters, method of making .....xxvii (08) 709  
 high-tension lines, practice.....xxiii (04) 592  
 inductance .....xxvii (08) 728  
 resistance, effect of salt, tests.....xxvii (08) 715  
 tests under various conditions .....xxvii (08) 710  
 variation with depth, tests .....xxvii (08) 712  
 various soils, tests.....xxvii (08) 723
- indicator, connections .....xxii (03) 423
- pipe, permanence of conductance.....xxvi (07) 1213  
 relation between depth and conductance...xxvi (07) 1215  
 resistance, experimental investigation.....xxvi (07) 1209  
 tests under various conditions...xxvi (07) 1219  
 specification .....xxvii (08) 726
- plates, copper, resistance tests.....xxvi (07) 1217  
 resistance tests under various conditions...xxvi (07) 1219  
 resistance variation with moisture, tests.....xxvi (07) 1210  
 temperature, tests...xxvi (07) 1210
- rod (see Lightning rod).
- shield for transformers.....xxiii (04) 553  
 objections .....xxiii (04) 554
- wire, advantages .....xxvii (08) 449  
 barbed, experience .....xxii (03) 342  
 conductance, importance.....xxiv (05) 995  
 effect on dielectric stresses, study.....xxvi (07) 873  
 effectiveness...xxv (06) 415, 428; xxvi (07) 884; xxvii (08) 429, 449; xxix (10) 598, 607, 613, 614  
 energy loss due to inductance.....xxii (03) 337  
 equipotential lines about.....xxvi (07) 875  
 experience.....xxii (03) 370; xxvi (07) 888; xxvii (08) 414, 761  
 Taylor's Falls line.....xxvii (08) 414  
 with barbed wire.....xviii (01) 539  
 grounded neutral, objections.....xxii (03) 405, 414  
 installation .....xxii (03) 335  
 parallel potential nearby, equation.....xxvi (07) 876  
 pole-top construction .....xxvi (07) 434  
 potential nearby, equation.....xxvi (07) 874

- Ground, wire, (*continued*)
- practice .....XXIII (04) 592
  - protective zone .....XXIV (05) 995
  - resistance tests under various conditions.....XXVI (07) 1219
  - shielding action calculation.....XXII (03) 333, 345
  - spacing of grounds.....XXVII (08) 430
  - support, construction .....XXVII (08) 418
- Grounded neutral, advantages.....XXVI (07) 1586, 1597, 1631
- bibliography .....XXVI (07) 1618
  - dangers .....XXII (03) 405
  - directions for grounding.....XXVI (07) 178
  - disadvantages.....XXVI (07) 1588, 1597, 1631
  - effect on harmonics.....XXV (06) 702
  - lightning arrester perform-  
ance.....XXVI (07) 1587, 1622
  - short circuits .....XXVI (07) 1600
  - synchronous converter opera-  
tion .....XXIII (04) 350
  - telephone and telegraph  
lines .....XXVIII (09) 1195
  - transformer insulation.....XXII (03) 386
  - experience, Chicago Edison Co.....XXVI (07) 1611
  - Int. Rapid Transit Co.....XXVI (07) 1605
  - transmission line.....XXVI (07) 1635
  - method of connecting parallel operated  
star-connected generators .....XXIX (10) 805
  - objections .....XXII (03) 414
  - potential strains .....XXII (03) 401
  - resistance used by Chicago Edison Co.....XXVI (07) 1613
  - series resistor, design.....XXVI (07) 1606
  - effect .....XXVI (07) 1592
  - size .....XXVI (07) 1600
  - use of ground as return.....XXVI (07) 1588
  - value of resistance used by Int. Rapid  
Transit Co. ....XXVI (07) 1606
- Group drive (see Motors, applications).
- switch (see Switches).
- Guanajuato transmission line, construction data.....XXVI (07) 1239
- Gyraton, radius of wheels.....XIX (02) 166
- Hair, human, diameter .....XXV (06) 819
- Hall effect, definition .....XXVI (07) 959
- electronic theory .....XXVI (07) 958
- Harbor defense, account of work done by Volunteer Elec-  
trical Corps in Boston.....XIX (02) 727
- Harmonic quantities, vector representation.....XXIX (10) 1242
- Harmonics, artificial, sources in cable system.....XXVIII (09) 835
- effect of grounded neutral.....XXV (06) 702
  - star-connected generator.....XXV (06) 704
  - transformer connections.....XXV (06) 700
- even, production in commercial circuits.....XXVIII (09) 727, 733
- in transformers, interconnected, explanation.....XXIX (10) 900
- observation.....XXIX (10) 853
  - currents and e. m. f.'s., tests.....XXIX (10) 809
  - observed during service.....XXIX (10) 873
  - polyphase, observation.....XXIX (10) 865
- triple, in interconnected neutral of star-  
connected generators, measurement.....XXIX (10) 781

Hartford Electric Light Co. turbo-generator installation,		
description .....	XXI (03)	450
Havana, Cuba, automatic telephone plant.....	XXIX (10)	79
Headlight, electric, early use.....	XXI (03)	173
experimental investigation .....	XXIX (10)	1053
high-power, effect on reading signals.....	XXIX (10)	1054
vs. low-power .....	XXIX (10)	1084
illumination at different distances, determina-		
tion .....	XXIX (10)	1066
fixed point, determination.....	XXIX (10)	1061
location on locomotive.....	XXIX (10)	1084
magnetite arc, tests.....	XXIX (10)	1082
photometrical measurements .....	XXIX (10)	1061
spectral intensities .....	XXIX (10)	1075
spectrophotometric analysis, different types.....	XXIX (10)	1069
total flux, determination.....	XXIX (10)	1063
Heat dissipated from wires, experiments.....	XXVIII (09)	363
storage of electric energy.....	XXVII (08) 1600; XXIX (10)	678
Heater, electric, hot-water, cost compared with equivalent		
fuel heater .....	XXVII (08)	655
life of elements.....	XXVII (08)	655
radiation, maximum capacity.....	XXVII (08) 1604,	1612
Heating, cables in ducts.....	XXIV (05)	409
coal gas, efficiency, theoretical.....	XXVII (08)	1591
stove, efficiency .....	XXVII (08)	1605
curve, bare wire in sand.....	XXVI (07)	990
data, method of plotting.....	XXVIII (09)	537
dissipation in ventilated cores.....	XXVIII (09)	533
electric compared with gas.....	XXVII (08)	1592
cooking (see Cooking).		
domestic work .....	XXVII (08)	1596
energy required to heat given space.....	XXVII (08)	1587
general discussion .....	XXVII (08)	1585
hot-water, fuel equivalent of electric		
energy .....	XXVII (08)	667
system at Biltmore.....	XXVII (08)	652
industrial work .....	XXVII (08)	1596
large building, cost.....	XXVII (08)	1602
radiation, maximum capacity of heat-		
ers .....	XXVII (08) 1604,	1612
gas, compared with electricity.....	XXVII (08)	1592
laminations, heat conductivity.....	XXVIII (09)	533
motor, induction, effect of enclosing.....	XXVIII (09)	551
high-reactance rotor.....	XXVIII (09)	539
varying dimensions.....	XXVIII (09)	543
speed.....	XXVIII (09)	547
voltage unbalance.....	XXVIII (09)	582
heat conductivity of cores.....	XXVIII (09)	533
investigation .....	XXVIII (09)	527
running, tests .....	XXVIII (09)	533
starting, tests .....	XXVIII (09)	531
temperature-loss diagram.....	XXVIII (09)	539
steam, by-product effect on cost of energy.....	XXIX (10)	121
thermodynamic .....	XXVII (08) 1607,	1609
wires under various conditions of cooling.....	XXVI (07)	969
Heaviside's method of explaining wave motion.....	XXVII (08)	1312
Hefner lamps (see Lamps).		

Heraeus wire temperature coefficient of resistivity.....xxv	(06)	485
Hering's flux unlinking experiment.....xxvii	(08)	1343
laws for electrode losses.....xxix	(10)	463, 492
Hewlett link insulator, construction.....xxvi	(07)	1261
description.....xxvi	(07)	1259
Heyland diagram for single-phase motor, derivation..xxiii	(04)	435, 440
Hickley electrolytic rectifier for telegraph work.....xxix	(10)	1315
High-tension committee report on standard line construction.....xxiii	(04)	571
Hoe printing press, motor drive.....xx	(02)	136
Hoists (see Hoisting).		
acceleration, calculation.....xxix	(10)	295
coal, acceleration curves, observed.....xx	(02)	142
power requirements.....xx	(02)	139
Ward Leonard system, disadvantages.....xx	(02)	191
conical-drum, load diagrams.....xxix	(10)	263
calculation.....xxix	(10)	300
static moment, variation, calculation.....xxix	(10)	302
cylindrical-drum, load diagrams.....xxix	(10)	261
calculation.....xxix	(10)	292
cylindro-conical-drum, load diagrams.....xxix	(10)	264
d. c. motor, induction-motor-generator set, characteristics.....xxix	(10)	272
drum, inertia, calculation.....xxix	(10)	304
electric, Ilgner system compared with steam tests..xxix	(10)	331
service tests.....xxix	(10)	328
windage loss.....xxix	(10)	335
induction motor, characteristics.....xxix	(10)	268
motor power, calculation.....xxix	(10)	323
rating, determination.....xxix	(10)	323
friction torque, calculation.....xxix	(10)	296
log, typical.....xxix	(10)	282
mine, acceleration, choice.....xxii	(03)	559
balancing system, requirements.....xxix	(10)	308
electric, balancing system, characteristics...xxix	(10)	313
Koepe, load diagram, calculation.....xxix	(10)	298
load curve.....xxv	(06)	152
diagrams, calculation.....xxix	(10)	295
motors, choice of control.....xxii	(03)	558
power requirements.....xxii	(03)	555
Whiting, load diagram, calculation.....xxix	(10)	298
reel, load diagram.....xxix	(10)	257
calculation.....xxix	(10)	307
retardation, calculation.....xxix	(10)	295
steam, coal-to-rock ratio, tests.....xxix	(10)	332
compared with Ilgner electric system, tests.....xxix	(10)	331
service tests.....xxix	(10)	331
Ward Leonard system, connection diagram.....xx	(02)	141
service tests.....xx	(02)	141
Hoisting, electric, motor rating, determination.....xxix	(10)	323
mine, balancing system, requirements.....xxix	(10)	308
converter system, description.....xxix	(10)	310
electric, advantages.....xxix	(10)	251, 322
balancing system, characteristics..xxix	(10)	313
characteristics, d. c. motor, motor-generator system.....xxix	(10)	272

- Hoisting, mine, electric, (*continued*)
- characteristics, induction motor
    - system .....XXIX (10) 268
    - compared with steam.....XXIX (10) 287
    - converter equalizer, use.....XXIX (10) 279
    - Creplet system .....XXIX (10) 281
    - economy, estimated .....XXIX (10) 319
    - flywheel-motor-generator set, use.XXIX (10) 275
    - Ilgner system .....XXIX (10) 275
      - compared with
        - steam tests.....XXIX (10) 331
        - service tests.....XXIX (10) 328
        - windage loss.....XXIX (10) 335
    - Johannesburg plant .....XXIX (10) 291
    - load-factor .....XXIX (10) 283
    - motor rating, determination.....XXIX (10) 323
    - reversible booster system, de-
      - scription .....XXIX (10) 312
      - savings, estimated .....XXIX (10) 289
    - Winona Copper Co. plant.....XXIX (10) 327
    - load diagrams .....XXIX (10) 256
    - power distribution among hoists.....XXIX (10) 283
    - steam, coal-to-rock ratio, tests.....XXIX (10) 332
      - compared with electric.....XXIX (10) 287
      - service tests .....XXIX (10) 331
    - time characteristics .....XXIX (10) 283
  - Homopolar generators (see Generators, acyclic).
  - Horn-gap arrester (see Lightning arresters).
  - Hospitalier ondograph, description.....XXIV (05) 193
  - Hot water electric heating (see Heating).
  - Hot-wire comparator (see Comparator).
  - Housatonic river, minimum flow.....XXV (06) 184
  - Houston and Kennelly luminometer (see Luminometer).
  - Huber system of current collection (see Current collectors).
  - Hudson river, minimum flow.....XXV (06) 184
  - Hulett unloader, control system.....XXVIII (09) 943
  - Hunting, alternators, angular displacement, standard.....XXIII (04) 353
    - cause .....XVIII (01) 757
    - natural frequency of mechanical
      - oscillation .....XXIII (04) 354
    - remedy .....XVIII (01) 757
    - tests, light and heavy flywheels.....XXIII (04) 354
    - effect of flywheel upon engine governor.....XXIII (04) 357
    - natural period of engine-generator unit,
      - formula .....XXIII (04) 360
    - prevention, dampers, action.....XVIII (01) 786
    - synchronous apparatus, effect of flywheel.....XXIII (04) 359
      - converters, effect of commutating
        - poles .....XXIX (10) 1642
        - experience .....XXIII (04) 345
  - Hutchinson method of calculating temperature rise of
    - railway motors .....XXII (03) 661
  - Hydrogen, liquefaction .....XXIV (05) 1018
  - Hysteretic angle of advance, definition.....XXV (06) 707



Hysteresis, angle relation to hysteresis loop area.....xxv (06)	684
exponent, variation with flux density....xxviii (09)	455, 458
loop area relation to hysteretic angle of	
advance .....xxv (06)	684
from exciting current wave.....xxv (06)	675
plotted from exciting current wave...xxix (10)	844
study .....xxix (10)	896
losses, effect of direction of rolling.....xxviii (09)	462
variation with flux density.....xxviii (09)	455, 458
Ice difficulties, Niagara Falls.....xxiv (05)	837
troubles, precautions at Niagara Falls.....xxiv (05)	811
Ilgner electric hoisting system.....xxix (10)	275
mine hoist, tests.....xxix (10)	327
Illuminants, comparison different types.....xx (02)	104
Illumination art, practical side.....xix (02)	5
calculation, including reflection.....xx (02)	73
diffusing globe, formula for radius.....xix (02)	10
effect of wandering arc.....xix (02)	33
experimental room, equipment.....xx (02)	95
indoors, requirements .....xix (02)	24
industrial plants .....xxix (10)	139
intensity, drafting rooms.....xxix (10)	143
indoor targets .....xxix (10)	142
machine shop .....xxix (10)	143
railway cars .....xxi (03)	175
intrinsic brilliancy, importance.....xix (02)	8
light, steadiness, importance.....xix (02)	7
measurement, direct method.....xx (02)	75
methods of operating illuminants.....xix (02)	17
outdoor, characteristics of arcs.....xix (02)	20
primary standards, general characteristics...xix (02)	14
retinal persistence, value .....xix (020)	7
street, incandescent lamps, advantages.....xix (02)	45
minimum intensity .....xix (02)	38
relation between size and spacing of	
arc lamps .....xix (02)	38
small vs. large units.....xix (02)	38
study, equipment of room.....xx (02)	95
units .....xix (02)	16
visual usefulness, criterion.....xix (02)	9
Illinois Central Railway Co. dynamometer car, description..xix (02)	867
Steel Co., Gary Plant (see Gary Plant).	
South Chicago power plant, description.xxiv (05)	55
Image conductor, explanation .....xxviii (09)	1230
Impedance formula, series circuits.....xxvii (08)	1397
Imperial valley irrigation system.....xxix (10)	732
Inaccuracy cost .....xxviii (09)	1277
Incandescence, theory .....xxv (06)	789
Incandescent lamps (see Lamps).	
Indiana Union Traction Co. distribution system, tests....xxii (03)	243
energy consumption, tests....xxii (03)	181
lines, map .....xxiv (05)	963
power plant, description....xxii (03)	467
plan and ele-	
vation.....xxii (03)	469
service capacity, tests.....xxii (03)	202
transmission and distribu-	
tion circuits .....xxii (03)	244

- Inductance, armatures, a. c., observed.....XXIII (04) 327  
     winding, calculation .....XXIII (04) 302  
     cables, armored, formula .....XXVIII (09) 764  
         formulas .....XXVIII (09) 764  
         single-conductor, formula .....XXVI (07) 560  
     parallel wires, formula derivation.....XXVI (07) 556  
     measurements .....XXV (06) 720  
     multiple conductors, formulas.....XXVIII (09) 678  
     reactive coils, formula .....XXV (06) 888  
     transmission line, formula...XXIII (04) 663; XXVI (07) 163  
         theory .....XXIII (04) 661  
 Induction, alternators, effect of slot shape.....XXIII (04) 269  
     electromagnetic, electronic theory.....XXVI (07) 957  
         Faraday's law .....XXVII (08) 1341  
         general law .....XXVII (08) 1352  
         Hering's unlinking experi-  
             ment .....XXVII (08) 1343  
         J. J. Thomson's statement of  
             law .....XXVII (08) 1342  
         Maxwell's statement of law.XXVII (08) 1341  
     generators (see Generators, a. c. induction).  
     magnetic, parabolic law, derivation.....XXV (06) 707  
     motors (see Motors).  
     regulator (see Regulator).  
     watt-hour meter (see Meter, watt-hour).  
 Industries, electrical, distribution of capital in U. S.....XXIX (10) 650  
 Instability, general definition .....XXVIII (09) 39  
 Instruments, ammeters (see Ammeters).  
     equipment New York Edison Co. generators.XXII (03) 431  
         railway substation .....XXII (03) 246  
     frequency meter (see Meter).  
     high-tension, electrical properties.....XIX (02) 219  
     inaccuracy, cost .....XXVIII (09) 1277  
     jewel pressure in practice.....XXIV (05) 245  
     power-factor meters (see Power-factor meters).  
     range choice .....XXIV (05) 243  
     switchboard, calibration method.....XVIII (01) 169  
         d. c. standardizing in place...XVIII (01) 183  
         equipment, Niagara Falls plant.XVIII (01) 497  
         location .....XXIV (05) 240, 830  
     testing telegraph circuits.....XXIX (10) 1333  
     transformers (see Transformers).  
     various (see name of instrument).  
     voltmeters (see Voltmeters).  
     water-cooled electro-dynamometer.....XXIX (10) 1547  
     watt-hour meter (see Meters).  
     Weston, characteristics .....XXIV (05) 232  
 Insulation, 500,000 volts .....XXVIII (09) 221  
     bibliography .....XXIX (10) 1580  
     breakdown, effect of local heating.....XXIX (10) 1592  
     cable, cotton-beeswax, experience.....XXVI (07) 597  
         cotton-dry core, experience.....XXVI (07) 597  
         dielectric conduction .....XIX (02) 1067  
         effect of duration of charge on capacity.XXIX (10) 1612  
             duration of charge upon insu-  
                 lation resistance.....XXIX (10) 1610  
         load on dielectric stress.....XXIX (10) 1600

- Insulation, cable, effect of (*continued*)
- load on specific capacity and
    - temperature .....XXIX (10) 1600
    - temperature on capacity.....XXIX (10) 1613
    - temperature gradient in equalizing dielectric stress.....XXIX (10) 1622
    - temperature on insulation resistance .....XXIX (10) 1611
  - graded, design curves.....XXIX (10) 1560
  - grading formulas .....XXIX (10) 1577
  - history .....XXIX (10) 1556
  - methods of distributing potential stresses .....XXIX (10) 1554
  - paper, capacity, change with temperature .....XXIV (05) 407
  - disadvantages .....XXVI (07) 603
  - insulation resistance change with
    - temperature .....XXIV (05) 406
    - temperature, maximum limit.....XXII (03) 420
  - potential distribution .....XXVIII (09) 210
  - rubber, insulation resistance change
    - with temperature.....XXIV (05) 404
    - temperature, maximum limit.....XXII (03) 420
  - Russel's grading formulas.....XXIX (10) 1557
  - stress distribution, effect of temperature.XXIX (10) 1566
  - thickness used in various high-tension systems .....XXVII (08) 1504
  - condenser type .....XXVIII (09) 209
  - dielectric strength .....XXVIII (09) 236
  - potential distribution.....XXVIII (09) 235
  - gradient, equations.XXVIII (09) 241
  - weak spots .....XXVIII (09) 221
  - conductance, effect of stress distribution.....XXIX (10) 1564
  - laws .....XXIX (10) 1607
  - corona phenomena (see Corona).
  - deterioration with number of lightning strokes..XXV (06) 390
  - dielectric strength, relation to duration of
    - stress .....XXVI (07) 1204
    - time element .....XVIII (01) 423
  - disruptive stroke tests.....XXV (06) 379
  - early experiments on dielectric strength.....XXIX (10) 1608
  - effect of joint in dielectric circuit.....XXIX (10) 1585
  - generators, graded .....XXIX (10) 1593
  - graded, design curves.....XXIX (10) 1560
  - effect of dielectric energy.....XXIX (10) 1605
  - formulas .....XXIX (10) 1577
  - history .....XXIX (10) 1556
  - Russel's formulas .....XXIX (10) 1557
  - ionization theory of solid dielectrics.....XXIX (10) 1582
  - mechanical action of dielectric stress.....XIX (02) 1069
  - problem, high-tension lines .....XVIII (01) 367
  - puncture tests .....XXV (06) 369
  - rubber cable, insulation resistance tests.....XXV (06) 200
  - puncture tests .....XXV (06) 200
  - choice of potential .....XXV (06) 203
  - capacity, change with temperature.....XXIV (05) 404
  - characteristics .....XXV (06) 193

Insulation, rubber (*continued*)

compound qualities, desirable.....	xxvi (07)	1009
durability, relation to electrical prop- erties .....	xxv (06)	209
effect of ozone.....	xviii (01)	535
elasticity as index of quality.....	xxv (06)	221
different qualities, tests.....	xxv (06)	219
insulation resistance as index of quality .....	xxv (06)	204, 221
insulation resistance, change with tem- perature, tests .....	xxv (06)	217
insulation resistance, change with test e. m. f., tests .....	xxv (06)	217, 220
insulation resistances for different sizes of wire, table.....	xxv (06)	226
properties, effect of chemical compo- sition .....	xxvi (07)	1013
puncture e. m. f. as index of quality.....	xxv (06)	214, 221
different qualities.....	xxv (06)	218
resistivity, heat .....	xxvi (07)	982
specific capacity as index of quality.....	xxv (06)	221
change with tempera- ture, tests .....	xxv (06)	218
for different sizes of wire, table.....	xxv (06)	226
specification .....	xxv (06)	199, 230
for 30 per cent. para compound .....	xxv (06)	211
temperature coefficient of capacity as index of quality.....	xxv (06)	221
temperature coefficient of resistivity as index of quality.....	xxv (06)	221
wire, insulation resistance tests.....	xxv (06)	200
puncture tests .....	xxv (06)	200
choice of potential.....	xxv (06)	203
stress distribution, effect of temperature.....	xxix (10)	1566
surge tests .....	xxv (06)	369
temperature, effect on performance.....	xix (02)	1050
rise measurement .....	xix (02)	1049
transformers, advantages of micanite.....	xxix (10)	712
condenser type .....	xxviii (09)	220
effect of triple frequency e.m.f.....	xxix (10)	860
extra, on end turns, construc- tion .....	xxvi (07)	1174
graded .....	xxix (10)	1602
reinforcement of end turns.....	xxvi (07)	1175
weatherproof, life out-of-doors.....	xxii (03)	761
wire, capacity measurement.....	xxvi (07)	999
dielectric loss different types, tests.....	xxvi (07)	1005
formula .....	xxvi (07)	998
gutta percha, breakdown e. m. f.....	xxiv (05)	413
resistance, tests .....	xxvi (07)	1005
resistivity, heat .....	xxvi (07)	982
specific capacity of different types, tests.....	xxvi (07)	1005
thickness for various surface stresses, table .....	xxvi (07)	173

Insulators, behavior under lightning conditions.....	xxvii	(08)	426
brush discharge, effect on insulation quality.....	xxii	(03)	356
charge accumulation tests.....	xxv	(06)	369
distribution of stress, mechanical analogy.....	xxix	(10)	1587
effect of strains on dielectric strength.....	xxix	(10)	1618
entry, construction, 50,000-volt.....	xxii	(03)	325
failures, record, Taylor's Falls line.....	xxvii	(08)	407
glass, relative advantages of lead and potash.....	xxi	(03)	312
heating caused by potential strain.....	xxii	(03)	354
line, arcing rings, tests.....	xxix	(10)	593
cost .....	xxiii	(04)	544
design for early Niagara line.....	xviii	(01)	514
factors .....	xxiii	(04)	160
dew test .....	xxvii	(08)	954
dimensions, degree of accuracy.....	xxvii	(08)	957
dielectric stress distribution.....	xxiii	(04)	162
dirt, effect on insulation.....	xxi	(03)	316
effect of blast from steam locomotives.....	xxvii	(08)	1620
fog .....	xxix	(10)	718
equivalent circuit diagram .....	xxvii	(08)	922
experience .....	xxix	(10)	573
of Pacific Gas & Electric Co.....	xxix	(10)	718
factor of safety, choice.....	xxix	(10)	603, 605
glass, electrical tests .....	xxi	(03)	314
vs. porcelain .....	xxi	(03)	276
link type .....	xxvi	(07)	1259
construction .....	xxvi	(07)	1261
suspension .....	xxvi	(07)	1267
potential distribution between disks .....	xxvi	(07)	1271
losses at different e. m. f's. ....	xxiv	(05)	343
classification .....	xxvii	(08)	927
effect of length of wooden pin.....	xxvii	(08)	883
vapor product.....	xxvii	(08)	877
measurement .....	xxiv	(05)	351
under wet and dry conditions.....	xxvii	(08)	880
method of locating broken.....	xxvi	(07)	1320, 1330
porcelain, electrical tests.....	xxi	(03)	314
vs. glass .....	xxi	(03)	276
protection (see Lightning).			
arcing effects .....	xxix	(10)	593
rings, tests .....	xxix	(10)	593
overhead grounded wire.....	xxix	(10)	598
relief gaps, experience.....	xxix	(10)	581
relief gaps, experience.....	xxix	(10)	581
resistance, ohmic .....	xxvii	(08)	927
soot, effect on insulation.....	xxi	(03)	316
steam test .....	xxvii	(08)	954, 957
suspension type, arcing rings.....	xxix	(10)	597
testing .....	xxvii	(08)	945
design .....	xxvii	(08)	949
experience .....	xxi	(03)	239
rain gauge, design.....	xxvii	(08)	948, 954
routine .....	xxvii	(08)	949
troubles on Ontario Power Co.'s lines.....	xxix	(10)	578
types used on high-tension.....	xxiii	(04)	582
nigger-head .....	xxviii	(09)	247

Insulators, (*continued*)

pins, charring, photographs.....	XXI (03)	253
prevention .....	XXI (03)	292
cost .....	XXIII (04)	544
design .....	XXI (03)	263, 305
diameter calculation, formula.....	XXI (03)	234
dimensions .....	XXI (03)	265, 268
eucalyptus, strength .....	XXI (03)	300
treating, method.....	XXI (03)	267
fastening for high-tension lines.....	XXIII (04)	585
fiber stresses .....	XXI (03)	233
iron, construction .....	XXI (03)	272
locust, strength.....	XXI (03)	299, 300
tests .....	XXI (03)	266
material for high-tension lines.....	XXIII (04)	585
oak, strength .....	XXI (03)	300
steel grounded vs. wood.....	XXVI (07)	1252
standard dimensions .....	XXI (03)	234
strength .....	XXVII (08)	941
tests .....	XXI (03)	269, 272
Niagara Falls pole line.....	XVIII (01)	520
treatment for high-tension lines.....	XXIII (04)	585
wooden, charring, photographs.....	XXI (03)	253
insulating value .....	XXI (03)	289
vs. steel grounded.....	XXVI (07)	1252
potential strains, classification.....	XXII (03)	354
section, catenary construction, types.....	XXIX (10)	1004
steady strain, catenary construction, types.....	XXIX (10)	1000
strain, 600-volt, specification, N. Y. C. R. R.....	XXIX (10)	1035
11,000-volt, specification, N. Y. C. R. R.....	XXIX (10)	1034
Brooklyn type, breakdown e. m. f.....	XXII (03)	239
catenary construction, types.....	XXIX (10)	1002
composition .....	XXII (03)	240
e. m. f. breakdown, tests.....	XXII (03)	234
general specifications .....	XXII (03)	239
globe type, breakdown e. m. f.....	XXII (03)	239
tensile strength.....	XXII (03)	239
goose egg, mechanical strength, test.....	XXIX (10)	973
ideal .....	XXIX (10)	970
insulation resistance, tests.....	XXII (03)	237
link type .....	XXVI (07)	1268
moulded, depreciation .....	XXIX (10)	974
specifications .....	XXII (03)	241
tensile strength, tests.....	XXII (03)	232
wooden, advantages .....	XXIX (10)	974
telephone for circuits paralleling high-tension lines .....	XXIX (10)	723
tests, e. m. f. application methods.....	XXII (03)	365
measurement .....	XXII (03)	365
regulation .....	XXI (03)	312
precautions .....	XXII (03)	357
trolley, heating tests.....	XXII (03)	235
Insurance, reliability, cost analysis.....	XXVIII (09)	65
Inter. Rapid Transit Co. double-grate boiler construction.....	XXVI (07)	1716
experience, high-tension cables.....	XXII (03)	433
high-tension cable, trouble record.....	XXVII (08)	1534
power plant, description.....	XXIX (10)	183

Inter, Rapid Transit Co. ( <i>continued</i> )		
record of performance of signal		
system .....	XXIV (05)	590
subway signal system.....	XXVI (07)	1543
International Telegraph Conference, objections to regu-		
lations .....	XXVII (08)	619
Inter poles (see Commutating poles).		
Interrupter, static (see Static).		
Wehnelt, mode of operation.....	XIX (02)	293
Intrinsic brilliancy, experiments under various daylight		
conditions .....	XIX (02)	9
physiological importance .....	XIX (02)	8
Inventing as a profession.....	XXV (06)	520
part of engineer's work.....	XXV (06)	542
method of procedure.....	XXV (06)	523
Inventions, classification .....	XXV (06)	522
definition .....	XXV (06)	521
pioneer .....	XXV (06)	543
Inventors, classification .....	XXVIII (09)	332
compensation .....	XXVIII (09)	335
Ions, nature .....	XXV (06)	766
negative .....	XXVI (07)	949
positive .....	XXVI (07)	949
Ionization, theory .....	XXVI (07)	950
solid dielectrics .....	XXIX (10)	1582
Iron, cast, magnetization curve.....	XVIII (01)	468
tool cutting rates.....	XX (02)	124
conductivity, electric, at high temperatures.....	XXIX (10)	512
heat, at high temperatures.....	XXIX (10)	512, 536
elastic limit of galvanized wire.....	XXIII (04)	514
electrolysis when embedded in concrete, change in		
resistance .....	XXVI (07)	238
electrolysis when embedded in concrete, tests.....	XXVI (07)	232
electrolytic, magnetic properties.....	XXV (06)	462, 468
effect of tempera-		
ture .....	XXV (06)	464
physical properties .....	XXV (06)	460
purity obtainable .....	XXV (06)	460
expansion coefficient .....	XXIII (04)	514
losses, aging tests .....	XXVIII (09)	466
dynamo electric machines, calculation.....	XXVIII (09)	993
experimental investigation of armatures.....	XXII (03)	445
revolving machines, calculation.....	XXVIII (09)	1000
tests, errors from wave distortions.....	XXVIII (09)	418
sine wave, results.....	XXVIII (09)	417
specimens, requirements.....	XXVIII (09)	446
wave distortion, cause.....	XXVIII (09)	442
testing apparatus, Bureau Standards.....	XXVIII (09)	444
commercial methods.....	XXVIII (09)	468
Epstein vs. Lloyd methods.....	XXVIII (09)	468
modulus of elasticity of wire.....	XXIII (04)	514
resistance, electric, variation, when embedded in		
concrete, tests .....	XXVI (07)	238
resistivity, electric, at high temperatures.....	XXIX (10)	512
temperature coefficient.....	XXIX (10)	537
heat, at high temperatures.....	XXIX (10)	512, 536
temperature coefficient.....	XXIX (10)	537
tarnishing in vacuum, explanation.....	XXV (06)	856

Iron, ( <i>continued</i> )		
tensile strength of wire.....	XXIII (04)	514
Iron-loss voltmeter.....	XXVIII (09)	424, 427
Irrigation, California, typical system, description.....	XXIX (10)	737
changes, Mount Whitney Power Co.....	XXIX (10)	739
effect on land values.....	XXIX (10)	751
gravity compared with ground water system.....	XXIX (10)	733
ground water compared with gravity system.....	XXIX (10)	733
pumping, load characteristics.....	XXIX (10)	742
power requirements .....	XXIX (10)	742
project investment value.....	XXIX (10)	752
relation to hydroelectric plants.....	XXXVIII (09)	1435, 1471
water power .....	XXVIII (09)	1363
systems, Imperial, San Joaquin and Sacra- mento valleys .....	XXIX (10)	732
Mount Whitney Power Co.....	XXIX (10)	737
Texas .....	XXIX (10)	759
Isolated plants, cost of energy production compared with central plants .....	XXIX (10)	131
Isophotal curves, definition .....	XX (02)	74
Jablochhoff candle, features.....	XXVIII (09)	16
James river drainage area.....	XXIV (05)	793
rainfall .....	XXIV (05)	794
run-off .....	XXIV (05)	794
Janesville Electric Co. hydroelectric transmission system, description .....	XXV (06)	585
Jewel pressure in instrument practice.....	XXIV (05)	245
Johannesburg mines, electric hoisting plant, description.....	XXIX (10)	291
Johnson adjustable reluctance motor, magnetism distri- bution .....	XIX (02)	1138
coil, definition .....	XXIX (10)	1322
Joubert point-by-point wave meter, description.....	XXIV (05)	186
Jungfrau three-phase railway, description.....	XVIII (01) 115; XIX (02)	503
Kal, definition .....	XXVII (08)	1588
Kern river transmission line, construction data.....	XXVII (08)	943
Kinematics of train movement.....	XXII (03)	135
Kinetic efficiency, definition .....	XXV (06)	56
Koepe mine hoist, load diagram, calculation.....	XXIX (10)	298
Körting gas engine, description.....	XXVIII (01)	85
Laboratories, engineering, classification.....	XXIV (05)	1051
instruction, general method.....	XIX (02)	1160
Laminations, armature, thickness, Niagara generator No. 1 .....	XXVIII (01)	472
Lamps, acetylene burner, construction.....	XIX (02)	52
gas, specific consumption.....	XX (02)	107
arc, carbon, a. c. power consumption.....	XXVIII (01)	877
enclosed, a. c. candle-power.....	XXVIII (01)	559
power-factor .....	XXVIII (01)	559
specific consumption.....	XXVIII (01)	559
candle-power curves.....	XIX (02)	30
characteristics .....	XIX (02)	20
compared with open.....	XIX (02)	29
d. c. candle-power.....	XXVIII (01)	559
specific consumption.....	XXVIII (01)	559
illumination curves.....	XIX (02)	30
power-factor .....	XXIV (05)	882



Lamps, arc, carbon, (*continued*)

open, candle-power curves.....XXVIII	(09)	47
characteristics...XIX (02) 19; XXVIII	(09)	4
compared with enclosed.....XIX	(02)	29
floating length, definition...XXVIII	(09)	5
illumination curves.....XIX	(02)	30
power-factor.....XXIV	(05)	883
specific consumption.....XXV	(06)	791
volt-ampere characteristic.....XXV	(06)	804
characteristics.....XXV	(06)	809
d.c. power consumption.....XVIII	(01)	877
effect of wandering arc on illumination.....XIX	(02)	33
electrode feed, drop and light system.....XXVIII	(09)	20
e. m. f. variation, maximum.....XXIV	(05)	376
flame, characteristics.....XXV	(06)	811
intrinsic brilliancy.....XXVI	(07)	628
inverted, method of lighting.....XIX	(02)	83
Jablochhoff candle, features.....XXVIII	(09)	16
magnets, regulating effect.....XXVIII	(09)	6
magnetite, volt-ampere characteristic.....XXV	(06)	804;
XXVIII (09) 40, 48		
volt-ampere characteristic, equa-		
tion.....XXVIII	(09)	44
mercury, volt-ampere characteristics.....XXVIII	(09)	47
photometric comparison of open and closed.....XIX	(02)	29
specific consumption.....XX	(02)	107
carbon filament, 220-volt, candle-power.....XXIV	(05)	457
English, characteristics.XXIV	(05)	457
accuracy in photometrical meas-		
urements.....XX	(02)	92
candle-power at different specific		
consumptions...XXIX	(10)	936
depreciation.....XXIX	(10)	1719
effect of e. m. f.		
variation.....XXV	(06)	822
variation with e. m. f. XX	(02)	80, 82
characteristics, general.....XIX	(02)	47
color composition of light.....XXIX	(10)	1726
initial current, oscillogram.....XXV	(06)	824
intrinsic brilliancy.....XX	(02)	72
life, 220-volt.....XXIV	(05)	460
resistance.....XXIX	(10)	931
specific consumption.....XX	(02)	107;
XXV (06) 792		
220-volt...XXIV	(05)	457
effect of		
e. m. f...XXV	(06)	822
spectral intensity.....XXIX	(10)	1073
temperature limit.....XXV	(06)	791
voltage candle-power, charac-		
teristic.....XVIII	(01)	560
specific consumption,		
characteristic.....XVIII	(01)	561
Edison X-Ray.....XXI	(03)	337
demonstration.....XIX	(02)	67
gas, Argand, intrinsic brilliancy.....XX	(02)	72

Lamps, (*continued*)

graphitized filament, candle-power depreciation.....XXIX	(10)	1719
effect of e.m.f.		
variation.....XXV	(06)	822
flicker tests .....	XXV (06)	844
resistance .....	XXIX (10)	930
specific consumption.....XXIV	(05)	847
effect of e.m.f.		
variation.....XXV	(06)	822
Hefner (see Light, standards).		
incandescent, energy efficiency.....XXV	(06)	789
filaments (see Filaments).		
flicker, method of overcoming.....XX	(02)	26
first used on war-ship.....XIX	(02)	579
intrinsic brilliancy .....	XXVI (07)	628
rating, three-voltage plan.....XXIX	(10)	944
resistivity, temperature coefficient,		
effect on regulation.....XXV	(06)	822
mercury vapor (see Arc).		
a. c., performance characteristics..XXV	(06)	615
account of development.....XIX	(02)	59
Cooper-Hewitt, description.....XXII	(03)	75
development .....	XXII (03)	72
early types .....	XXII (03)	72
effect of diameter of tube.....XIX	(02)	60
length of tube.....XIX	(02)	60
e. m. f. equation .....	XXV (06)	805
loss at negative, effect of		
temperature .....	XXV (06)	605
losses in tube.....XXV	(06)	602
variation allowable.....XXII	(03)	86
first .....	XXII (03)	71
patent .....	XXII (03)	72
intrinsic brilliancy .....	XXVI (07)	628
life.....XXII (03) 87; XXVI (07)		648
methods of starting.....XXII	(03)	82
negative electrode resistance,		
nature .....	XIX (02)	62
performance characteristics.....XXV	(06)	613
specific consumption..XIX (02) 59; XX	(02)	107;
XXV (06)		613
starting characteristics.....XXV	(06)	606
theory of operation.....XXV	(06)	601
volt-ampere characteristic.....XXV	(06)	627
work done by Cooper-Hewitt.....XXII	(03)	73
metal filament, first commercial.....XXIX	(10)	927
method of comparing various kinds.....XXVI	(07)	633
Moore tube, carbon-dioxide, specific consumption.XXVI	(07)	620
description Engineering Societies		
Bldg. installation.....XXVI	(07)	607, 657
feeder valve, construction.....XXVI	(07)	610
operation .....	XXVI (07)	610
frequency range .....	XXVI (07)	632
installation .....	XXVI (07)	624
intrinsic brilliancy .....	XXVI (07)	628
length limitation .....	XXVI (07)	621
nitrogen, specific consumption.....XXVI	(07)	621
photometry .....	XXVI (07)	615

Lamps, Moore tube ( <i>continued</i> )		
portable type	XXVI (07)	626
power-factor	XXVI (07)	621, 656
tests, Engineering Societies Bldg.		
installation	XXVI (07)	658
working temperature	XXVI (07)	637
Nernst, automatic, ballast, construction	XVIII (01)	70
mode of operation	XVIII (01)	68
ballast, a. c., life	XVIII (01)	566
candle-power	XVIII (01)	559
depreciation	XVIII (01)	581
commercial introduction	XVIII (01)	545
cut-out, construction	XVIII (01)	555
demonstration	XIX (02)	68
flicker, critical frequency	XVIII (01)	584
glowers, a. c., life	XVIII (01)	566
candle-power	XVIII (01)	63
characteristics	XVIII (01)	63
composition	XVIII (01)	63
d. c., life	XVIII (01)	581
ignition temperature	XVIII (01)	552
intrinsic brilliancy	XX (02)	72
life	XVIII (01)	63
method of manufacture	XVIII (01)	546
specific consumption	XVIII (01)	63
temperature	XVIII (01)	578
volt-ampere characteristic in		
hydrogen	XVIII (01)	550
volt-ampere characteristic in		
nitrogen	XVIII (01)	549
volt-ampere characteristic in		
oxygen	XVIII (01)	550
volt-ampere characteristic in		
vacuum	XVIII (01)	547
volt-ampere time characteristics		
in vacuum	XVIII (01)	551
heater, life	XVIII (01)	554
history	XVIII (01)	545
inspection	XVIII (01)	568
instability	XXVIII (09)	3
intrinsic brilliancy	XXVI (07)	628
maintenance	XVIII (01)	566
men responsible for development	XVIII (01)	545
power-factor	XVIII (01)	559
rating	XVIII (01)	555
repairs	XVIII (01)	566
six-glower, connections	XVIII (01)	557
description	XVIII (01)	556
specific consumption	XVIII (01) 558; XX (02)	107
starting current-time characteristic	XVIII (01)	563
volt-ampere characteristic	XVIII (01)	552
voltage candle-power characteristic	XVIII (01)	560
specific consumption character-		
istic	XVIII (01)	561
osmium filament, inventor	XVIII (01)	75
life	XVIII (01)	75
resistance	XXIX (10)	930

Lamps, osmium filament, (*continued*)

specific consumption.....	xviii (01)	75;
	xxv (06)	792
Pentane (see Light, standards).		
tantalum filament, candle-power at different		
specific consumptions.....	xxix (10)	936
candle-power depreciation.....	xxix (10)	1719
candle-power distribution.....	xxv (06)	824
candle-power, effect of		
e. m. f. variation.....	xxv (06)	822
color composition.....	xxv (06)	840
first commercial.....	xxix (10)	927
initial current, oscillogram.....	xxv (06)	824
life curves .....	xxv (06)	832
resistance .....	xxix (10)	930
specific consumption.....	xxv (06)	792, 831;
	xxix (10)	927
specific consumption, effect		
of e. m. f. variation.....	xxv (06)	822
spherical reduction factor.....	xxv (06)	831
tungstate of calcium, demonstration.....	xix (02)	67
tungsten filament, blackening.....	xxix (10)	952
candle-power at different spe-		
cific consumptions.....	xxix (10)	936
candle-power depreciation.....	xxix (10)	953, 1719
candle-power distribution.....	xxv (06)	824
candle-power, effect of e. m. f.		
variation .....	xxv (06)	822
candle-power relation to e. m. f.....	xxix (10)	938
color composition.....	xxv (06)	840; xxix
	(10)	1726
commercial rating.....	xxix (10)	942
cooling curves.....	xxix (10)	946, 1720
first .....	xxix (10)	928
flicker, critical frequency.....	xxix (10)	1728
frequency, observed.....	xxix (10)	949
low frequency.....	xxix (10)	934
tests .....	xxv (06)	846
life .....	xxix (10)	942
at different specific con-		
sumptions .....	xxix (10)	937
correction factors for dif-		
ferent e. m. f's. ....	xxix (10)	954
curves .....	xxv (06)	836
effect of flashing sign		
service .....	xxix (10)	945
relation to e. m. f.....	xxix (10)	938
manufacturing methods.....	xxix (10)	1710
overshooting .....	xxix (10)	941
sign flashing service.....	xxix (10)	1720
specific consumption.....	xxv (06)	792, 857
specific consumption, effect of		
e. m. f. variation.....	xxv (06)	822
specific consumption, relation		
to e. m. f. ....	xxix (10)	938
street lighting .....	xxix (10)	939
vacuum tube (see Lamps, Moore tube).		
characteristics .....	xxv (06)	800

Land reclamation, method of changing.....	xxvii (08)	478
Lansing, St. John & St. Louis Electric Ry. overhead construction .....	xxiv (05)	110
Latour self-exciting compound alternator.....	xxi (03)	569
Laundry, electric equipment, Biltmore, description.....	xxvii (08)	656
Leakage, alternator, effect of design factors.....	xxii (03)	51
coefficient, definition .....	xxiii (04)	307
low-speed alternators .....	xxii (03)	52
currents from railways (see Stray currents).		
reactance induction motors (see Motors).		
Leggo automatic telegraph .....	xxix (10)	1310
Lehigh canal, electric haulage.....	xxvii (08)	277
University, method of teaching engineering.....	xxvi (07)	1461
Library dinner .....	xxi (03)	97
Lecco, Londrio & Chiavenna three-phase railway, description .....	xviii (01)	102
Light, color composition, tantalum filament.....	xxv (06)	840
tungsten filament .....	xxv (06)	840
corpuscular theory of radiation.....	xxv (06)	851
definition .....	xxvii (08)	1319
energy, measurements, difficulties .....	xxvii (08)	1332
germicide action .....	xxi (03)	394
intensity, standard radiation energy, criticism.....	xxvii (08)	1320
requirements .....	xxvii (08)	1320
mechanical equivalent .....	xxvii (08)	1330, 1338
methods of producing.....	xix (02)	76
natural, average tint.....	xix (02)	11
production by electro luminescence.....	xix (02)	77
selective radiation .....	xix (02)	77
radiation, limit of efficiency.....	xxv (06)	862
red, small-pox treatment .....	xxi (03)	396
standards, acetylene burner, construction.....	xix (02)	52
Fery burner .....	xix (02)	57
Fessenden burner .....	xix (02)	57
flame, luminous intensity.....	xix (02)	53
spectro-photometric measurements .....	xix (02)	54
flame, sources of error.....	xix (02)	86
Hefner lamp, accuracy.....	xix (02)	81, 90
ideal qualities .....	xix (02)	56
Pentane lamp, accuracy.....	xx (02)	91
requirements .....	xxvii (08)	1320
ultra-violet, production .....	xxi (03)	397
treatment of disease .....	xxi (03)	393
wave propagation .....	xix (02)	570
Lighting, arc, development, history.....	xxviii (09)	4
churches, chief requirements.....	xxv (06)	644
illumination intensity .....	xxv (06)	644
specifications .....	xxv (06)	646
drafting rooms .....	xxix (10)	143
experimental room, equipment.....	xx (02)	95
factories, choice of illuminant.....	xxix (10)	144
wiring .....	xxix (10)	170
first man-of-war with incandescent lamps.....	xix (02)	579
indirect, general discussion.....	xx (02)	71
indoors, requirements .....	xix (02)	24
industrial, choice of illuminant.....	xxix (10)	144

Lighting, industrial, (*continued*)

plants .....	XXIX	(10)	139
processes, value .....	XXIX	(10)	139
load curve, summer.....	XXV	(06)	149
winter. ....	XXV	(06)	150
machine shops .....	XXIX	(10)	143
methods of operating illuminants.....	XIX	(02)	17
Moore tube system, Engineering Societies Bldg., description .....	XXVI	(07)	657
tests .....	XXVI	(07)	658
outdoor, choice of illuminants.....	XIX	(02)	22
enclosed arc, characteristics.....	XIX	(02)	20
open arc, characteristics.....	XIX	(02)	19
street (see Illumination).			
arc lamps, relation between size and spacing .....	XIX	(02)	38
criticism of actual value.....	XIX	(02)	43
incandescent lamps, advantages.....	XIX	(02)	45
small vs. large units.....	XIX	(02)	38
tungsten lamps .....	XXIX	(10)	934
targets, indoor .....	XXIX	(10)	142
train, acetylene, cost.....	XXI	(03)	208
axle-driven .....	XXI	(03)	134
Bliss system .....	XXI	(03)	134
bucket regulator.....	XXI	(03)	164
cost .....	XXI	(03)	208
actual .....	XXI	(03)	209
compared with engine-driven.....	XXI	(03)	193
compound solenoid regulator.....	XXI	(03)	199
disadvantages .....	XXI	(03)	177
efficiency .....	XXI	(03)	194
essential requirements.....	XXI	(03)	164
experience .....	XXI	(03)	216
Farnsworth system.....	XXI	(03)	164
Gould system.....	XXI	(03)	208
McElroy system.....	XXI	(03)	197
variable-resistance regulator.....	XXI	(03)	165
weights .....	XXI	(03)	194
batteries, cost .....	XXI	(03)	176, 208
disadvantages .....	XXI	(03)	175
experience .....	XXI	(03)	182
limitations .....	XXI	(03)	179
weights .....	XXI	(03)	176
Bliss system .....	XXI	(03)	134
circuit diagram.....	XXI	(03)	145
method of operation.....	XXI	(03)	142
earliest applications in U. S.....	XXI	(03)	156
early applications of electricity.....	XXI	(03)	173
engine-driven, attendance cost.....	XXI	(03)	195
compared with axle-driven.....	XXI	(03)	193
disadvantages .....	XXI	(03)	176
efficiency .....	XXI	(03)	194
experience .....	XXI	(03)	186
weights .....	XXI	(03)	194
Farnsworth system, circuit diagram.....	XXI	(03)	169
space requirements.....	XXI	(03)	172
Gould system .....	XXI	(03)	208
McElroy system .....	XXI	(03)	197

Lighting, train, ( <i>continued</i> )		
oil, cost .....	XXI (03)	208
Pintsch gas, cost.....	XXI (03)	208
turbine-driven .....	XXI (03)	226
value in industrial processes.....	XXIX (10)	139
Lightning arresters, aluminium (see Cell).		
care .....	XXVIII (09)	848
characteristics .....	XXVII (08)	708
current and e. m. f. oscil-		
lograms .....	XXV (06)	897
arc-extinguishing quality, test.....	XXV (06)	393
arc-suppressing devices .....	XXVI (07)	1086
breakdown test .....	XXVI (07)	1103
characteristics .....	XXVI (07)	1072
classification .....	XXV (06)	399
definition .....	XXIV (05)	993
design, effect of duration of dis-		
charge .....	XXVI (07)	1068
principles .....	XXVI (07)	461
disruptive tests .....	XXV (06)	379
e. m. f. control.....	XXV (06)	387
frequency control.....	XXV (06)	387
method .....	XXVI (07)	1075
elements .....	XXIV (05)	982
endurance test .....	XXVI (07)	1081
equipment, Animas Power & Water		
Co. ....	XXVII (08)	701
high-tension substation.....	XXVI (07)	1308
Friese discharger .....	XXIV (05)	948
gas and fuse, current and e. m. f.		
oscillograms .....	XXV (06)	896
Gola system .....	XXIV (05)	945
graded resistor type.....	XXV (06)	912
ground connections .....	XXIII (04)	592
method of mak-		
ing .....	XXVII (08)	709
half-wave test.....	XXV (06) 395; XXVI (07)	1080
high-frequency single, test .....	XXVI (07)	1078
high-tension, electrical properties.....	XIX (02)	219
horn-gap, advantages .....	XXVII (08)	450
characteristics .....	XXVI (07)	432
with series		
resistor.....	XXVII (08)	454
without series		
resistor.....	XXVII (08)	454
construction .....	XXIV (05)	939
experience, Taylor's Falls		
line .....	XXVII (08)	416
selective .....	XXV (06)	903
theory .....	XXVI (07)	487
ideal, requirements .....	XXVI (07)	449
impedance measurement .....	XXVI (07)	1108
inspection methods .....	XXVI (07)	1053
investigation with tell-tale papers.....	XXIV (05)	976
Italian high-tension lines.....	XXIV (05)	945

Lighting arresters, (*continued*)

liquid electrode, construction.....xxvi	(07)	472
operation .....	xxvi (07)	472
oscillograms of per-		
formance .....	xxvi (07)	484
location in transmission line.....xix	(02)	253
low-equivalent, design .....	xxvi (07)	461
experience.....xxvii	(08)	436, 763
experience, Taylor's		
Falls line.....xxvii	(08)	416
laws of operation.....xix	(02)	1026
non-arcing power,		
relation to circuit		
conditions .....	xix (02)	1026
principles of opera-		
tion .....	xix (02)	1022
maximum possible discharge from		
given line .....	xxvi (07)	1127
multi-gap, effect of screening on per-		
formance .....	xxv (06)	919
series resistor.....xxv	(06)	400
shunt resistor.....xix	(02)	1030
tests.....xxv	(06)	402
experience .....	xxv (06)	353
with series and		
shunt resist-		
ers .....	xxvi (07)	490
graded resistance, current		
oscillogram .....	xxvi (07)	466
graded resistance, descrip-		
tion .....	xxvi (07)	450
graded resistance, experi-		
ence .....	xxvi (07)	1150
graded resistance, opera-		
tion, theory.....xxvi	(07)	454
non-arcing power, calcula-		
tion .....	xxv (06)	436
non-arcing power, condi-		
tions that affect.....xix	(02)	1024
non-arcing power, tests.....xxvi	(07)	1132
operation, theory.....xxvi	(07)	438
selective action, explana-		
tion .....	xxv (06)	431
series resistor, effect on		
performance .....	xxv (06)	386
shunt resistors, function...xxvi	(07)	448
shunting power of resist-		
ors, tests .....	xxvi (07)	1136
theoretical investigation.....xxv	(06)	448
use of series resistors.....xix	(02)	251
shunt resistors.....xix	(02)	251
non-arcing power, tests.....xxvi	(07)	1118
Pearson-Cutcheon static discharger,		
connections .....	xxiv (05)	959
performance, actual .....	xxiv (05)	951
effect of grounded		
neutral.....xxvi	(07)	1587, 1622



Lighting arresters, (*continued*)

- resistors, equivalent gap determina-
  - tion .....xxv (06) 381, 917
- sensitiveness, test....xxv (06) 393; xxvi (07) 1080
- series impedance, function.....xxvi (07) 1104
  - resistance, maximum.....xxv (06) 893
- spacing along transmission line.....xxvi (07) 1314
- spark-gap (see Spark gap).
  - fuse, selective.....xxv (06) 916
- tell-tale papers, instructions for use..xxiv (05) 951
  - interpretation .....xxvii (08) 411
  - method of fireproof-
    - ing .....xxvii (08) 781
  - rules for interpreta-
    - tion .....xxvii (08) 755
- tests, classification .....xxv (06) 368
  - in service .....xxvi (07) 1139
  - methods.....xxv (06) 365; xxvi (07) 1102
- analytical study .....xxvii (08) 421
- artificial, introduction into transmission line...xxvi (07) 1141
  - production .....xxvi (07) 1141
- characteristics, classification .....xxvii (08) 671
- conductors (see Lightning rods).
- current, calculation .....xxvii (08) 680
  - definition.....xxv (06) 365; xxvi (07) 402, 492;
    - xxvii (08) 799
  - measurement .....xxvii (08) 679
- discharge, abruptness of wave front.....xxvii (08) 776
  - quantity, measurement.....xxvii (08) 687
- disturbances, area of action.....xxvii (08) 415, 435, 792
  - causes .....xxiii (04) 565
  - duration .....xxvi (07) 1067
  - effect of insulation.....xxiv (05) 983
    - line location.....xxv (06) 428
  - series inductance on
    - potential distribution
      - in transformer wind-
        - ings .....xxv (06) 886
      - steel towers.....xxiii (04) 524, 537
      - topography .....xxvii (08) 450
    - on insulators .....xxvii (08) 426
  - experience, New Milford Power
    - Co. ....xxv (06) 349
  - frequencies involved.....xxvi (07) 1062
  - investigation, list of participating
    - companies .....xxiv (05) 955
  - line-to-line, experience.....xxvii (08) 440
  - mechanical analogy.....xxv (06) 881
  - possible sources.....xxiv (05) 322
  - record, Presumpscot Electric Co..xxvii (08) 446
    - Taylor's Falls system.....xxvii (08) 408
  - relation to line e. m. f.....xxvi (07) 1051, 1206
  - theory .....xxii (03) 331; xxvii (08) 421
  - wooden vs. metal cross-arms.....xxvii (08) 699
- duration .....xxvi (07) 1067
  - measurement .....xxvii (08) 672
- effect of frequency upon disruptive power.....xxv (06) 372
  - on choke coils .....xxv (06) 906

Lighting (*continued*)

- frequency, measurement .....XXVII (08) 681
  - recording meter, description.....XXVII (08) 684
- origin, theory .....XXVII (08) 773
- penetration distance into transformer winding.....XXVI (07) 1195
  - tests, transmission line.....XXVII (08) 691
- phenomena, characteristics .....XXVII (08) 770
  - classification.....XXV (06) 367; XXVI (07) 401
- photographs .....XXVI (07) 426
- potential measurement .....XXVII (08) 676
  - meters, description .....XXVII (08) 678
- protection, advantages of choke coils.....XXVI (07) 1191, 1192
  - catenary structures .....XXIX (10) 1005
  - choke coils, danger.....XXVI (07) 1194
    - design .....XXVI (07) 1207
    - effectiveness.....XXV (06) 410, 914; XXVII (08) 431
    - tests...XIX (02) 259; XXVI (07) 1194, 1203
  - experience.....XXIII (04) 564; XXV (06) 924
  - functions .....XXIII (04) 566
  - in line, experience.....XXVII (08) 763
    - oil, objections.....XXVI (07) 1201
  - location.....XXV (06) 902; XXVI (07) 1197
- definitions of terms.....XXVI (07) 1056
- engineering, glossary of terms.....XXVI (07) 1056
- equivalent needle-gap, determina-  
tion .....XXVI (07) 1074
- generators, frame insulation.....XXVI (07) 372
- grounded rods (see Lightning rods).
  - effectiveness .....XXVII (08) 430
- wire (see Ground wire).
  - effectiveness.....XXVII (08) 414, 429, 449
- inductance required for different  
voltages .....XXV (06) 890
- line-to-line discharger, installation.....XXIV (05) 989
- location of devices on distribution  
system .....XXII (03) 750
- methods .....XXVIII (09) 1163
- outdoor stations, grounded wires.....XXVIII (09) 235
- practice in Italy.....XXIV (05) 948
- problem, statement .....XXVI (07) 422
- record of disturbances on Taylor's  
Falls line .....XXVII (08) 408
- static interrupter, effectiveness.....XIX (02) 259
- transmission line, spacing of arrest-  
ers .....XXVI (07) 1314
- recorder for transmission lines.....XXVII (08) 692
- rods for buildings, installation.....XXVII (08) 730
  - catenary structures .....XXIX (10) 1005
  - construction .....XXVII (08) 418
  - effectiveness .....XXVII (08) 430
  - experience, Taylor's Falls line.....XXVII (08) 415
  - on Guanajuato line.....XXVI (07) 1241
  - line poles, experience.....XXVII (08) 762

Lighting rods ( <i>continued</i> )		
pole-top, construction .....	XXVI (07)	434
stroke, effect on transmission lines.....	XXVII (08)	424
time-element in destruction.....	XXV (06)	430
striking distance.....	XXV (06)	430
Lime light, oxy-hydrogen, original.....	XIX (02)	82
Lincoln frequency meter, description.....	XVIII (01)	262
synchroscope, mode of operation.....	XVIII (01)	255
Linemen, rubber gloves, objections.....	XXII (03)	760
Lines, transmission (see Transmission).		
Link insulators (see Insulators).		
Liquid electrode lightning arrester (see Lightning arrester).		
element, definition .....	XIX (02)	310
Lissajous figures .....	XXIX (10)	896
Little Tennessee river, minimum flow.....	XXV (06)	184
Lloyd core-loss tester vs. Epstein apparatus.....	XXVIII (09)	468
iron-loss testing apparatus.....	XXVIII (09)	444
Load acceleration in railway work.....	XVIII (01)	645
characteristics, coast defenses.....	XIX (02)	673
Chicago, average daily .....	XVIII (01)	815
lighting and power, analysis.....	XVIII (01)	816, 818
city, per square mile.....	XVIII (01)	863
typical curve .....	XXVIII (09)	1382
curve, Buffalo .....	XVIII (01)	522
effect on cost of energy.....	XXVIII (09)	1489
with different prime movers .....	XXVIII (09)	1494
elevator service .....	XIX (02)	456
hoists, conical drum.....	XXIX (10)	263
calculation .....	XXIX (10)	300
cylindrical drum .....	XXIX (10)	261
calculation .....	XXIX (10)	292
cylindro-conical drum .....	XXIX (10)	264
Koepe, calculation .....	XXIX (10)	298
mine.....	XXV (06) 152; XXIX (10)	256
calculation .....	XXIX (10)	292
Whiting, calculation.....	XXIX (10)	298
reel .....	XXIX (10)	257
calculation .....	XXIX (10)	307
industrial .....	XXVIII (09)	1487
lighting .....	XXVIII (09)	1488
summer .....	XXV (06)	149
winter .....	XXV (06)	150
railway .....	XXV (06)	151
effect of high acceleration.....	XXIX (05)	475
interurban, substations.....	XXII (03)	256
Valtellina .....	XXIV (05)	493
residence section, typical.....	XXIX (10)	376
synchronous motors .....	XIX (02)	785
telephone exchange .....	XXI (03)	76
diagram, roll trains .....	XXIX (10)	1391
dispatcher system of central station operation.....	XXI (03)	439
description....	XXVIII (09) 1468; XXIX (10)	708
lighting, residential, maximum demand.....	XVIII (01)	280
Load-factor, Chicago Edison Co. ....	XVIII (01)	892
definition .....	XXV (06)	57
effect of battery, Chicago Edison Co.....	XVIII (01)	893
centralization of energy supply....	XXVIII (09)	356

Load-factor, effect (*continued*)

- on cost of electric energy production...XXII (03) 780;
    - xxv (06) 140; xxviii (09) 1400
  - electric energy with differ-
    - ent prime movers.....xxviii (09) 1494
  - economy of gas producers.....xxv (06) 58
    - steam turbine plant....xxv (06) 59
  - evaluation of hydroelectric plants...xxv (06) 139
  - operation and maintenance charges,
    - hydroelectric plant.....xxv (06) 141
  - operation and maintenance charges,
    - steam-electric plant .....xxv (06) 140
  - lighting stations .....xxiii (04) 786
  - mine hoists .....xxix (10) 283
  - railway power stations.....xxiii (04) 786
  - textile manufacturing processes.....xxix (10) 159, 163
- Locomotive, center of gravity, effect of height on track...xxix (10) 1426, 1441, 1445
- contractors, power requirements.....xxix (10) 368
  - effect of dead weight on track.....xxix (10) 1440, 1449
  - electric, a. c. compared with d. c.....xxvii (08) 1691
  - single-phase, 25 vs. 15 cycles...xxvi (07) 1396
  - single-phase, 25 and 15 cycles,
    - performance compared.....xxvi (07) 138
  - single-phase, acceleration char-
    - acteristics .....xxvi (07) 123
  - single-phase, description, 15-
    - cycle .....xxvi (07) 1390
  - single-phase, effect of fre-
    - quency on initial slip.....xxvi (07) 111
  - single-phase, effect of fre-
    - quency on ratio of tractive
      - effort to weight on drivers...xxvi (07) 106
  - single-phase, effect of fre-
    - quency on tractive effort....xxvi (07) 111
  - single-phase, log of mileage,
    - New Haven Road.....xxvii (08) 1653
  - single-phase, log of repairs,
    - New Haven road.....xxvii (08) 1649
  - single-phase, log of trailing
    - loads, New Haven road.....xxvii (08) 1655
  - single-phase, New Haven, center
    - of gravity .....xxvi (07) 756
  - single-phase, New Haven, com-
    - pared with New York Cen-
      - tral .....xxvii (08) 1694
  - single-phase, New Haven, de
    - scription .....xxvi (07) 751
  - single-phase, New Haven, power
    - characteristics .....xxvi (07) 115
  - single-phase, performance char-
    - acteristics .....xxvi (07) 1656
  - single-phase, power character-
    - istics compared with d. c. and
      - three-phase .....xxvi (07) 115
  - single-phase, speed character-
    - istics compared with d. c. and
      - three-phase .....xxvi (07) 115

Locomotive, electric, a. c. (*continued*)

- single-phase, speed-torque characteristics....xxvi (07) 118; xxvii (08) 1694
- single-phase vs. three-phase for
  - trunk lines .....xxviii (09) 1322
- single-phase, weight for 25 and 15 cycles.....xxvi (07) 742, 1388
- three-phase, acceleration characteristics.....xxvi (07) 122, 123, 124
- three-phase, acceleration tests....xix (02) 521
- three-phase, advantages.....xxviii (09) 1315
- three-phase, disadvantages.....xxviii (09) 1317
- three-phase, effect of driver
  - diameter .....xxiv (05) 554
- three-phase, efficiency, actual....xxiv (05) 503
- three-phase, four-speed, acceleration curve .....xxiv (05) 506
- three-phase, frictional resistance .....xxiv (05) 503
- three-phase, Great Northern,
  - control system .....xxviii (09) 1339
- three-phase, Great Northern,
  - design and performance.....xxviii (09) 1284
- three-phase, Great Northern,
  - starting requirements.....xxviii (09) 1341
- three-phase, life of bearings,
  - actual .....xxiv (05) 474
- three-phase, overload capacity..xxiv (05) 547, 556
- three-phase, performance on
  - different classes of service....xxiv (05) 544
- three-phase, performance tests....xix (02) 523
- three-phase, power characteristics .....xxvi (07) 115
- three-phase, power characteristics compared with d. c. and single-phase .....xxvi (07) 115
- three-phase, repairs, cost, Valtellina line .....xxvi (07) 61
- three-phase, speed characteristics .....xxvi (07) 115
- three-phase, speed characteristics compared with d. c. and single-phase .....xxvi (07) 115
- three-phase, speed-torque characteristics .....xxvi (07) 118
- three-phase, Valtellina, center
  - of gravity .....xxvi (07) 756
- three-phase, Valtellina, description .....xxvi (07) 745
- three-phase vs. direct-current..xxviii (09) 1329
- three-phase vs. single-phase for
  - trunk lines .....xxviii (09) 1322
- three-phase, weight efficiency
  - compared with d. c.....xxviii (09) 1342
- adhesion coefficient .....xxvi (07) 1647
  - practice .....xxvi (07) 1678

Locomotive, electric, adhesion (*continued*)

tests, independent and coupled		
drivers .....	XXIX (10)	1453
classification .....	XXIX (10)	1443
canal haulage tests, Lehigh canal....	XXVII (08)	277
compared with Mallet compound		
for mountain service.....	XXVI (07)	1679
coupled drivers, adhesion test.....	XXIX (10)	1453
d. c., acceleration characteristics.....	XXVI (07)	122
compared with a. c.....	XXVII (08)	1691
efficiency, actual .....	XXIV (05)	503
gearless, performance charac-		
teristics .....	XXVI (07)	1655
New York Central, center of		
gravity .....	XXVI (07)	756
New York Central compared		
with New Haven.....	XXVII (08)	1694
New York Central compared		
with Valtellina three-phase....	XXIV (05)	501
New York Central, description....	XXVI (07)	747
New York Central, power char-		
acteristics .....	XXVI (07)	115
New York Central, speed char-		
acteristics .....	XXVI (07)	115
performance B. & O. belt line....	XXVIII (09)	1330
different classes of		
service .....	XXIV (05)	544
power characteristics compared		
with single and three-phase....	XXVI (07)	115
speed characteristics compared		
with single-phase and three-		
phase .....	XXVI (07)	115
speed-torque characteristics.....	XXVI (07)	118;
XXVII (08)		1694
vs. three-phase .....	XXVIII (09)	1327
weight efficiency compared with		
three-phase .....	XXVIII (09)	1342
draw-bar pull, maximum, per axle....	XXVI (07)	1678,
1685, 1689		
driving gear, classification.....	XXIX (10)	1418
effect of location of springs on track		
disturbances .....	XXIX (10)	1450
eight-wheel double-truck, stress dis-		
tribution .....	XXIV (05)	596
rigid frame, stress dis-		
tribution .....	XXIV (05)	599
essential features .....	XXIX (10)	1415
fast freight service requirements....	XXIX (10)	1424
four-wheel with pony trucks, stress		
distribution .....	XXIV (05)	601
single-truck, stress dis-		
tribution .....	XXIV (05)	594
gears, life .....	XXIX (10)	1434
tooth pressure .....	XXIX (10)	1434
transmission .....	XXIX (10)	1432
gearless, concentric, inventor.....	XXVI (07)	135
motors, objec-		
tions .....	XXIX (10)	1431

Locomotive, electric, (*continued*)

high-speed passenger service requirements .....	XXIX (10)	1424
independent drivers, adhesion tests .....	XXIX (10)	1453
interchangeability for passenger and freight service .....	XXIX (10)	1430, 1448
maintenance cost, different tractive efforts .....	XXVI (07)	1659
mechanical design .....	XXVI (07) 1701; XXIX (10)	1415
mining efficiency, hauling canal boats .....	XXVII (08)	287
friction losses, hauling canal boats .....	XXVII (08)	289
operation cost at different tractive efforts .....	XXVI (07)	1659
mountain grades .....	XXVI (07)	1664
performance compared with steam .....	XXVI (07)	1643
plate frames, advantages .....	XXIX (10)	1451
power characteristics compared with steam .....	XXVI (07)	115
power-speed characteristics .....	XXVI (07)	1649
regenerative control (see Control).		
Scotch yoke, description .....	XXIX (10)	1437
side-rod drive .....	XXVIII (09)	1336
advantages .....	XXIX (10)	1435
gear combination drive, advantages .....	XXIX (10)	1438
slow freight service requirements .....	XXIX (10)	1422
speed characteristics compared with steam .....	XXVI (07)	115
speed-torque characteristics, various types .....	XXVI (07)	118
stress distribution in trucks .....	XXIV (05)	594
switching service requirements .....	XXIX (10)	1422
tonnage capacity on mountain grades .....	XXVI (07)	1666
trucks, stress distribution .....	XXIV (05)	594
tractive effort speed characteristics .....	XXVI (07)	1649
weight on drivers, utilization tests .....	XIX (02)	837
headlight, best location .....	XXIX (10)	1084
high-power vs. low-power, tests .....	XXIX (10)	1053
interchangeability for freight and passenger service .....	XXIX (10)	1430, 1448
mine, characteristics .....	XXVII (08)	1572
rating .....	XXVII (08)	1582
steam, adhesion coefficient .....	XXVI (07)	1647
practice .....	XXVI (07)	1678
Atlantic type, acceleration characteristics .....	XXVI (07)	123
power characteristics .....	XXVI (07)	115
speed characteristics .....	XXVI (07)	115
speed-torque characteristics .....	XXVI (07)	118
classification .....	XXIV (05)	563
cleaning, cost .....	XXVI (07)	67
coal consumption in suburban service, actual .....	XIX (02)	849

## TOPICAL INDEX

Locomotive, steam, (*continued*)

compound Mallet, compared with electric for mountain service .....	xxvi (07)	1679
steam consumption compared with simple.....	xxvi (07)	1667
Consolidation type, acceleration characteristics .....	xxvi (07)	124
power characteristics .....	xxvi (07)	115
speed characteristics .....	xxvi (07)	115
speed-torque characteristics .....	xxvi (07)	118
effect of blast on steel wire.....	xxvii (08)	1705
upon line insulators.....	xxvii (08)	1620
express service .....	xxiv (05)	565, 568
freight, daily mileage.....	xxvi (07)	64
fuel consumption, actual.....	xxvi (07)	146
maintenance, cost .....	xxvi (07)	112
repairs, cost .....	xxvi (07)	112, 1682
service .....	xxiv (05)	565, 568
frictional resistance .....	xxviii (09)	1307
fuel consumption, different types..	xxiv (05)	565, 568
local, express and freight service, tests .....	xxvi (07)	1681
mountain grades, tests .....	xxvi (07)	1661
cost .....	xxvi (07)	69
heating surface, different types.....	xxiv (05)	565, 568
maintenance cost.....	xxiii (04)	739; xxvi (07) 67, 1682
different tractive efforts .....	xxvi (07)	1652
Mallet compound, economy.....	xxviii (09)	1314, 1331, 1349
road tests .....	xxviii (09)	1331
mileage, daily .....	xxvi (07)	64
operation cost, different tractive efforts.....	xxvi (07)	1652
mountain grades.....	xxvi (07)	1664
Pacific type, acceleration characteristics .....	xxvi (07)	122
power characteristics.....	xxvi (07)	115
speed characteristics.....	xxvi (07)	115
passenger, daily mileage.....	xxvi (07)	64
fuel consumption, actual.....	xxvi (07)	146
maintenance, cost.....	xxvi (07)	112, 1682
repairs, cost.....	xxvi (07)	112, 1682
service .....	xxiv (05)	565, 568
performance compared with electric.....	xxvi (07)	1643
mountain grades.....	xxvi (07)	1653
power characteristics compared with electric .....	xxvi (07)	115
power-speed characteristics .....	xxvi (07)	1649
rate of evaporation.....	xxvi (07)	1651
repairs, cost, Manhattan Elevated.....	xxvi (07)	58
New Haven road.....	xxvi (07)	149



- Locomotive, steam, (*continued*)
- simple, Consolidation dimensions and weights .....xxvi (07) 1650
  - speed-tractive effort characteristics .....xxvi (07) 1646
  - speed characteristics compared with electric .....xxv (07) 115
  - speed-torque characteristics, various types .....xxvi (07) 118
  - steam consumption on mountain grades, tests .....xxvi (07) 1661
  - tonnage capacity on mountain grades.....xxvi (07) 1666
  - traction coefficient, maximum.....xxiv (05) 609
  - tractive effort, different types.....xxiv (05) 565, 568
  - speed characteristics.....xxvi (07) 1649
  - weights, different types.....xxiv (05) 565, 568
  - on drivers, utilization tests.....xix (02) 837
  - storage battery, advantages .....xxii (03) 109
  - calculation .....xxii (03) 113
  - battery rating.....xxii (03) 115
  - classification .....xxii (03) 111
  - control methods .....xxii (03) 120
  - speed regulation.....xxii (03) 126
  - wheels, radius of gyration.....xix (02) 166
  - slipping point, change due to internal action .....xxiv (05) 593
  - London, Brighton & South Coast Ry. double catenary construction .....xxvii (08) 1700
  - Long Island R. R. electric section, description.....xxiii (04) 691
  - map of electric section.....xxiii (04) 692
  - service tests .....xxiii (04) 706
  - signal system .....xxvi (07) 1545
  - Loop test, power cables, connections.....xviii (01) 901
  - Los Angeles Aqueduct, description.....xxix (10) 361
  - Losses, corona (see Corona).
  - eddy-current (see Eddy-current).
  - hysteresis (see Hysteresis).
  - Lubrication, bearings, large gas engines.....xxix (10) 433
  - Luminescence, definition .....xxvi (07) 967
  - maximum efficiency with vapors.....xxv (06) 798
  - theory .....xxv (06) 796
  - Luminometer, Burnett, description .....xx (02) 75
  - Houston & Kennelly, objections.....xx (02) 102
  - Luminous intensity, mean hemispherical, equation.....xviii (01) 678
  - horizontal, measurement with Matthews photometer.....xx (02) 65
  - spherical candle-power, determination .....xx (02) 60
  - spherical, equation .....xviii (01) 678
  - spherical, measurement with Matthews photometer.....xx (02) 68
  - spherical reduction factor, measurement with Matthews photometer....xx (02) 69
  - vertical distribution, measurement with Matthews photometer.....xx (02) 67
  - point, composition, Balmain's.....xxi (03) 334

Machines, electric, accuracy of construction.....	xxiv (05)	685
temperature records, value.....	xxix (10)	350
group drive, cost compared with individual.....	xx (02)	189
synchronous, natural frequency, calculation.....	xix (02)	794
Machine-shop, efficiency, effect of speed control.....	xx (02)	123
group drive, cost compared with single		
and individual .....	xx (02)	116
vs. independent motor drive.....	xx (02)	177
individual drive, cost compared with		
single and group.....	xx (02)	116
lighting .....	xxix (10)	143
single drive, cost compared with group		
and individual .....	xx (02)	116
work, classification .....	xx (02)	198
Machine-tools, choice of motor for different types.....	xxix (10)	628
controller, location .....	xxix (10)	632
drive, choice of speed control.....	xxix (10)	632
speed variation for given change in		
load with compound motor.....	xxvii (08)	322
speed variation for given change in		
load with series motor.....	xxvii (08)	322
speed variation for given change in		
load with shunt motor.....	xxvii (08)	322
group vs. individual drive.....	xx (02) 177; xxix (10)	641
importance of using standard motors.....	xxix (10)	630
individual drive, advantages.....	xx (02)	188
cost compared with group.....	xx (02)	189
motor applications, examples.....	xxix (10)	621
drive, advantages .....	xxix (10)	621
selection .....	xx (02)	203
size, determination .....	xx (02)	206
general rules.....	xx (02)	212
power consumption formulas, unreliability.....	xxix (10)	639
variation .....	xxix (10)	640
Magneto, hand, regulation curve .....	xxviii (09)	1181
Mains, losses in central station plant.....	xxvi (07)	678
Manganese, magnetic alloys .....	xxv (06)	468
Manhattan Elevated R. R., energy bill.....	xxix (10)	1487
energy losses in engine-type		
generators, tests.....	xix (02)	1057
speed-time curves, actual and		
calculated .....	xxiii (04)	725
coasting tests .....	xxix (10)	1482
high-pressure surge, explanation .....	xxiv (05)	363
mathematical investigation of		
surge .....	xxiv (05)	297
power plant circuit diagram.....	xxiii (04)	200
saving in coal consumption		
by electrification.....	xxviii (09)	167
Manholes, cable, construction, Niagara Falls Power Co.....	xxviii (01)	496
Martin mecograph, description.....	xxix (10)	1319
Matthews integrating photometer.....	xviii (01)	681
Maximum demand, residential lighting.....	xviii (01)	280
Mayer system overhead construction for railways.....	xxvi (07)	723
McElroy train lighting system.....	xxi (03)	197

- Measurements, a. c. astatic mutual inductance, construction .....XXIX (10) 1526  
 exact methods .....XXIX (10) 1517  
 heavy-current non-inductive shunts, construction .....XXIX (10) 1537  
 high-frequency .....XXIX (10) 1548  
 high-tension .....XXVII (08) 845  
 phase shifter, description.....XXIX (10) 1536  
 polyphase circuits .....XVIII (01) 283  
     objection to two-meter method .....XXIV (05) 176  
     objections to Wybach's method .....XXIV (05) 175  
     potentiometer, description.....XXIX (10) 1535  
     synchronous reversing key.....XXIX (10) 1518  
 d. c., large .....XVIII (01) 171  
 energy in polyphase circuits.....XVIII (01) 283  
     meters (see Meters).  
 e. m. f. with spark-gap, precautions.....XXVII (08) 1525  
 instruments (see name of instrument).  
 lightning phenomena .....XXVII (08) 672  
 with stroboscopic fork.....XXVII (08) 642  
 Mercury expansion, temperature coefficient.....XXV (06) 475  
     vapor converters (see Converters).  
 Merrimac river, maximum flow.....XXV (06) 184  
     watershed area .....XXV (06) 184  
 Metals, ductility, effect of chemical impurity.....XXIX (10) 962  
 Metallized filament lamps (see Lamps, graphitized filament).  
 Meter, phase, Arnos, mode of operation.....XVIII (01) 297  
     electrolytic, mode of operation.....XVIII (01) 293  
     induction, mode of operation.....XVIII (01) 292  
     Tuma's, mode of operation.....XVIII (01) 291  
 power-factor, Breitfield's, mode of operation.....XVIII (01) 299  
     Claude's mode of operation .....XVIII (01) 294  
     Dobrowolski's, description.....XVIII (01) 300  
     electrodynamometer, mode of operation .....XVIII (01) 296  
     Ferraris, mode of operation.....XVIII (01) 299  
     General Electric, mode of operation.....XVIII (01) 299  
     induction type, errors.....XXVII (08) 213  
     Morland's, mode of operation.....XVIII (01) 294  
     Puluy's, mode of operation.....XVIII (01) 293  
     Rayleigh's, mode of operation.....XVIII (01) 295  
     Siemen's dynamometer, performance .....XVIII (01) 301  
     Weston wattmeter, performance.....XVIII (01) 303  
 slip .....XXIV (05) 879  
 steam flow accuracy.....XXIX (10) 1695, 1707  
 wave, cathode tube, circuit diagram.....XXIII (04) 112  
     photographic records.....XXVIII (04) 114  
     continuous, Thomson, description.....XXIV (05) 187  
     General Electric, description.....XXIV (05) 192  
     Hospitalier, description.....XXIV (05) 193  
     oscillograph (see Oscillograph).  
     point-by-point, Joubert, description.....XXIV (05) 186  
     Rosa, description.....XXIV (05) 191

- Meter, (*continued*)  
 watt-hour accuracy, effect of instrument trans-  
   formers .....XXIV (05) 227  
   limits in service.....XXIV (05) 221  
   compensation for reactive current.....XVIII (01) 314  
   friction, effect of mechanical vibration..XVIII (01) 275  
   methods of minimizing.....XVIII (01) 273  
   relation to torque.....XVIII (01) 272  
   induction, performance as power-factor  
     meter .....XVIII (01) 305  
   installation .....XXIV (05) 181  
     plant cost, effect of diversity  
       friction .....XXIX (10) 383  
   polyphase, use.....XXIV (05) 166  
   rating, choice for different service....XVIII (01) 282  
     given service.....XXIV (05) 181  
   requirements .....XVIII (01) 277  
   rotating standard with several current  
     units .....XXIV (05) 215  
   selection .....XXIV (05) 181  
   Shallenberger performance as power-  
     factor meter .....XVIII (01) 305  
   torque relation to friction.....XVIII (01) 272  
   two-rate for peak load.....XVIII (01) 334  
   Westinghouse, calibration curve.....XVIII (01) 283
- Metropolitan District Ry., London, description of third  
 and fourth rails .....XXVII (08) 1215
- Mexico Republic, telegraph system.....XXIX (10) 1343
- Mica, dielectric strength, effect of oil.....XIX (02) 1065  
   with thickness .....XIX (02) 1066
- Micanite, advantages as transformer insulation.....XXIX (10) 712
- Micro-photographs, different grades of copper.....XXII (03) 701
- Michigan Agriculture College, automatic telephone plant..XXIX (10) 74
- Milan, central station system.....XVIII (01) 827
- Mills, advantages in buying electric energy.....XXIX (10) 126, 132  
   induction motor requirements.....XXIX (10) 147  
   lighting, choice of illuminant.....XXIX (10) 144  
   wiring .....XXIX (10) 170
- Mines, cable, acid proof covering.....XXVII (08) 1582  
   coal, Central Pennsylvania, character.....XXVII (08) 1571  
   Connellsville, character .....XXVII (08) 1571  
   electrical equipment of various plants in  
     Pennsylvania and West Virginia.....XXVII (08) 1574  
     tools, description .....XXVII (08) 1573  
   exhaust turbines, use.....XXVII (08) 1582  
   methods of mining in Pennsylvania.....XXVII (08) 1571  
   Pittsburgh character .....XXVII (08) 1571  
   uses of electric energy.....XXVII (08) 1571  
   electric plants, laying out.....XVIII (01) 192  
   gold, American Nettie, electric equipment.....XVIII (01) 196  
     plant .....XVIII (01) 193  
     hydraulic construction for  
       power plant.....XVIII (01) 193  
     power plant equipment....XVIII (01) 194  
   hoisting (see Hoisting).  
   submarine requirements for successful operation....XIX (02) 564
- Mirrors, transmission coefficient, equation.....XVIII (01) 684

Mississippi river, estimated power.....	XXVII (08)	380
maximum flow .....	XXV (06)	184
water-shed area .....	XXV (06)	184
Missouri River Power Co., insulator pins dimensions.....	XXI (03)	265
surge tests .....	XXIV (05)	338
Mobile river, run-off .....	XXIV (05)	799
Modulus of elasticity of various materials (see name of material).		
Molecule, dumb-bell, definition .....	XXVI (07)	961
Moment of inertia, connecting rod about its center, test.....	XVIII (01)	704
Moore tube lamp (see Lamps). lighting system, description.....	XXVI (07)	605
Morland's power-factor meter, mode of operation.....	XVIII (01)	294
Motors, a. c. commutator, bibliography.....	XXI (03)	568
choice of frequency for rail- way work .....	XXVI (07)	1377
commutation .....	XXVII (08)	36
compared with d. c. series for railway work .....	XXVI (07)	787
disadvantages .....	XXVII (08)	1686
effect of slot form on effective air-gap .....	XXVII (08)	153
efficiency .....	XXVI (07)	790
frequency, effect on adhesion coefficient .....	XXVI (07)	1380
Georges principle .....	XXI (03)	520
Heyland brush shift character- istics .....	XXI (03)	542
commutation, condi- tions .....	XXI (03)	526
construction .....	XXI (03)	529
excitation character- istics .....	XXI (03)	537
flux density, different parts .....	XXI (03)	555
generator character- istics .....	XXI (03)	551
load characteristics.....	XXI (03)	548
performance charac- teristics, variable excitation .....	XXI (03)	547
principle .....	XXI (03)	522
theory .....	XXI (03)	532
inherent differences from d. c. series .....	XXVI (07)	710
merits compared with d. c. series for railways.....	XXVI (07)	696
output compared with d. c. series .....	XXVI (07)	701
railway, classification .....	XXVII (08)	1
first in U. S.....	XX (02)	36
starting characteris- tics .....	XXVII (08)	1161
repulsion, air-gap .....	XXIII (04)	2
choice of frequency.....	XXVII (08)	15
circle diagram.....	XXIII (04)	53, 80

Motors, a. c. commutator, repulsion, (*continued*)

circuit diagram.....XXIII (04)	51
characteristics compared with series...XXIII (04)	30
characteristic performance, tests....XXIII (04)	3
commutation .....XXVII (08)	4
commutation (also see commutation).	
commutation principles .....XXVIII (09)	497
efficiency .....XXIII (04)	2
equation .....XXIII (04)	16
exciting impedance, calculation .....XXV (06)	287
first .....XXIII (04)	644
flux distribution....XXIII (04)	18
impedance e. m. f. losses .....XXIII (04)	38
inventors .....XXIII (04)	77
leakage compared with series.....XXIII (04)	47
performance, calculated .....XXIII (04)	40
performance characteristics .....XXV (06)	285
performance, effect of air-gap.....XXIII (04)	73
performance, effect of brush position..XXIII (04)	74
performance, effect of leakage.....XXIII (04)	72
performance equations .....XXIII (04)	20, 66
performance as generator, calculated..XXIII (04)	40
performance as generator, observed...XXIII (04)	39
performance, graphical representation.XXIII (04)	63
performance observed .....XXIII (04)	39
power-factor .....XXIII (04)	2
power-factor characteristics ....XXIII (04)	14, 32
railway, disadvantages .....XX (02)	44
series, brush, wear..XXVII (08)	40
characteristic curves ....XXVII (08)	42
series, commutation.XXVII (08)	3
series, running characteristics .....XXVII (08)	30
shunt, adjustable speed, characteristics .....XXVIII (09)	511

- Motors, a. c. commutator, repulsion, (*continued*)
- shunt, adjustable speed, performance observed ...XXVIII (09) 499, 505
  - shunt, adjustable speed, performance observed .....XXVIII (09) 523
  - shunt, adjustable speed, phase characteristics .....XXVIII (09) 519
  - shunt, adjustable speed, power-factor characteristics ...XXVIII (09) 519
  - shunt, armature speed control...XXVIII (09) 515
  - shunt, circle diagram, development .....XXVIII (09) 479
  - shunt, field speed control .....XXVIII (09) 516
  - shunt, speed control, inductance in field circuit .....XXVIII (09) 492
  - shunt, speed variation, methods...XXVIII (09) 477
  - speed-torque, characteristics .....XXV (06) 284
  - speed-torque characteristics .....XX (02) 33, 34
  - speed-torque curves.XXIII (04) 4
  - starting torque characteristics .....XXV (06) 278
  - Steinmetz-Schuler, circuit diagram ...XXIII (04) 87
  - theory .....XXV (06) 269
    - analytical ...XXIII (04) 56
    - speed control .....XXVIII (09) 475
  - Thomson, circuit diagram .....XXIII (04) 52
  - Thomson, theory...XXIII (04) 16
  - Winter-Eichberg, circuit diagram...XXIII (04) 88
  - working diagram...XXV (06) 270
  - series, arrangement for regenerative control .....XXVI (07) 1472
  - characteristics compared with repulsion .....XXIII (04) 30
  - choice of e. m. f. per field turn .....XXVII (08) 130
  - choice of frequency ...XXVII (08) 146
  - commutation .....XXVII (08) 137
    - troubles ...XXIX (10) 27
  - commutator life, New Haven Road.....XXVII (08) 1659
  - conductively compensated, circuit diagram.XXIII (04) 50
  - disadvantages .....XXIX (10) 24

Motors, a. c. commutator, series, (*continued*)

Eickemeyer .....	XXV (06)	346
Eickemeyer, design constants .....	XXIII (04)	11
Eickemeyer performance characteristics.....	XXIII (04)	12
Eickemeyer power-factor characteristics .....	XXIII (04)	14
external armature type, construction .....	XXIX (10)	32
external armature type performance .....	XXIX (10)	34
frequency of maximum economy .....	XXVI (07)	1400
induction regulator control .....	XX (02)	21
inductively compensated, circuit diagram.....	XXIII (04)	51
Lamme-Finzi, circuit diagram .....	XXIII (04)	86
Lamme type, history of development .....	XXIII (04)	636
leakage compared with repulsion .....	XXIII (04)	47
life of brushes .....	XXVII (08)	34
polyphase principles .....	XXI (03)	520
power-factor .....	XX (02)	25
power-factor .....	XXVII (08)	33
power-factor characteristics .....	XXIII (04)	32
railway, control methods.....	XX (02)	19
railway, performance characteristics .....	XX (02)	24
regenerative control compounding effect .....	XXVI (07)	1481
regenerative control connections .....	XXVI (07)	1477
regenerative control, motor requirements.....	XXVI (07)	1470
sparking, balanced choke coils, test .....	XXIX (10)	29
sparking prevention.....	XXIX (10)	28
speed-torque characteristics .....	XXIII (04)	34
straight, circuit diagram.....	XXIII (04)	50
theory .....	XXIII (04)	26
vector diagram .....	XXVI (07)	1527
single-phase induction, exciting impedance, calculation .....	XXV (06)	287
single-phase induction, performance characteristics.....	XXV (06)	285
single-phase induction, working diagram .....	XXV (06)	271
single-phase, starting characteristics .....	XXVII (08)	20, 29
single-phase, starting torque limit .....	XXIX (10)	48



Motors, a. c. commutator, (*continued*)

single-phase, weight, 25 and 15 cycles .....	XXVI (07)	1378
single-phase, weight compared with d. c. series.....	XXVI (07)	699, 1378
single-phase, weight factors, actual .....	XXIX (10)	49
design for bloom shears.....	XXVII (08)	332
elevator, choice .....	XIX (02)	460
induction, acceleration, maximum obtainable.....	XIX (02)	552
adjustable speed methods....	XXVIII (09)	601, 610
advantages in elevator service.....	XIX (02)	470
for interurban rail-ways .....	XVIII (01)	594
railway service.....	XVIII (01)	597
air-gap .....	XXIII (04)	2
calculation .....	XXIV (05)	656
effect on performance.....	XVIII (01)	596
for railway service.....	XIX (02)	550
selection .....	XXIV (05)	676
air-break vs. oil-break switches.....	XXIX (10)	168
American compared with Euro-pean .....	XVIII (01)	908
balancing effect .....	XXVIII (09)	1270
belt leakage reactance, formula.....	XXVI (07)	1493
tests.....	XXVI (07)	1500
characteristic, 2,000-hp. ....	XXVIII (09)	133
6,000-hp. ....	XXVIII (09)	132
compared with d. c.....	XVIII (01)	909
for railway work.....	XXVI (07)	704
coil end leakage, calculation.....	XXIV (05)	667
reactance, for-mula .....	XXVI (07)	1492
reactance, tests.....	XXVI (07)	1494
commutator, Atkinson.....	XXVIII (09)	475
compared with synchronous motor.....	XVIII (01)	372
comparison of three-phase and two-phase .....	XXV (06)	295
concatenated control, power con-sumption .....	XVIII (01)	627
energy return.....	XVIII (01)	656
concatenation .....	XXVIII (09)	604
internal.....	XXVIII (09)	603, 611, 613
construction compared with syn-chronous motor .....	XVIII (01)	372
control (see Control).		
cores, thermal conductivity.....	XXVIII (09)	533
cost compared with synchronous motor .....	XVIII (01)	379
current characteristics.....	XVIII (01)	428
current characteristics, compared with synchronous motor.....	XVIII (01)	374
current consumption, different sizes .....	XVIII (01)	905
current density, two and three-phase .....	XXV (06)	305
differential, concatenation.....	XIX (02)	528
factor, definition.....	XXVI (07)	1486

Motors, a. c. induction, (*continued*)

disadvantages .....	XVIII (01)	331
for railways.....	XIX (02)	544
transmission		
systems .....	XVIII (01)	420
efficiency, different sizes.....	XVIII (01)	905, 907
effect of frequency.....	XVIII (01)	905
elevator, energy consumption.....	XIX (02)	478
service .....	XIX (02)	454
e. m. f. relation to torque.....	XXVIII (09)	580
equations, method of teaching.....	XXI (03)	595
equivalent electric circuit.....	XXVII (08)	1413
European compared with Amer-		
ican .....	XVIII (01)	908
excitation, effect of fractional		
pitch winding .....	XXVI (07)	1525
exciting current calculation from		
volume of air-gap.....	XXV (06)	307
exciting reactance, tests.....	XXVI (07)	1502
felt leakage, calculation.....	XXIV (05)	670
field calculation .....	XXVII (08)	1386
space values, diagram.....	XXVII (08)	1375
time values, diagram.....	XXVII (08)	1376
flux density, selection.....	XXIV (05)	677
distribution in air-gap.....	XXIV (05)	919
distribution factors for two		
and three-phase.....	XXV (06)	296
in teeth, diagram.....	XXVII (08)	1373
flywheel, load characteristics....	XXVIII (09)	870
permanent vs. variable		
resistance rotor.....	XXVIII (09)	932
Gary plant, design data.....	XXVIII (09)	131
heat dissipation in ventilated		
cores .....	XXVIII (09)	533
heating calculations .....	XXVIII (09)	528
effect of bearing diam-		
eter .....	XXVIII (09)	545
diameter .....	XXVIII (09)	544
enclosing .....	XXVIII (09)	551
length .....	XXVIII (09)	543
speed .....	XXVIII (09)	547
voltage unbal-		
ance .....	XXVIII (09)	582
investigation .....	XXVIII (09)	527
starting, calculation of		
temperature .....	XXVIII (09)	554
tests, running.....	XXVIII (09)	533
starting .....	XXVIII (09)	531
industrial requirements.....	XXIX (10)	147
instability .....	XXVIII (09)	41
leakage coefficient, definition....	XXVI (07)	1505
effect .....	XXVI (07)	1513
factors, two and three-		
phase .....	XXV (06)	305
reactance, calculation.....	XXIV (05)	660
formulas .....	XXVI (07)	1488
magnetic circuits, electric equiva-		
lent .....	XXVI (07)	1506

## Motors, a. c. induction, (continued)

magnetizing current, calculation..xxiv	(05)	659;
	xxvii	(08) 1386
magnetizing current for two and three-phase .....	xxv	(06) 304
mechanical requirements.....	xxix	(10) 147
speed change.....	xviii	(01) 657
mill requirements .....	xxix	(10) 147
objections for railway service.xviii	(01)	595, 598
operation experience .....	xxix	(10) 147
troubles .....	xxix	(10) 147
causes .....	xxix	(10) 168
output, in terms of design con- stants .....	xxiv	(05) 652
performance calculation.....	xxvii	(08) 1413
performance characteristics com- pared with direct current.....	xviii	(01) 336
performance characteristics com- pared with synchronous motor..xviii	(01)	425
peripheral speed, selection.....	xxiv	(05) 678
permissible drop .....	xxiii	(04) 785
phase unbalance, study of effects.x xviii	(09)	559
polyphase, air-gap .....	xxiv	(05) 546
characteristics .....	xviii	(01) 613
first in U. S.....	xxviii	(09) 1320
overload capacity.....	xxiv	(05) 547
power-factor .....	xxiv	(05) 546
regulating effect on unbalanced circuits.xxviii	(09)	585
speed-torque charac- teristics .....	xx	(02) 33
voltage unbalance, study of effects.....	xxviii	(09) 559
power, effect of phase unbalance.xxviii	(09)	563
voltage unbalance....	xxviii	(09) 562, 576
power-factor characteristic, com- pared with syn- chronous motor..xviii	(01)	375
different sizes.....	xviii	(01) 906
effect of frequency.xviii	(01)	906
in terms of design constants .....	xxiv	(05) 650
power-time curves.....	xviii	(01) 616
railway, acceleration.....	xviii	(01) 323
air-gap .....	xxiv	(05) 546
efficiency .....	xviii	(01) 614
Ganz & Co., air-gap....	xviii	(01) 105
ideal conditions.....	xviii	(01) 599
power-factor .....	xviii	(01) 614
starting current.....	xviii	(01) 325
reaction on generator.....	xviii	(01) 375
regenerative control, tests.....	xxviii	(09) 1313
regulation required of generators.xviii	(01)	381
relation between slip and flywheel effect .....	xxviii	(09) 872
reliability .....	xviii	(01) 376

Motors, a. c. induction, (*continued*)

rheostatic control, power consumption .....	XXVIII (01)	625
rolling mill, control .....	XXVIII (09)	134
design data .....	XXVIII (09)	131
rotating field, characteristics .....	XXVII (08)	1380
rotor resistance, automatic regulation .....	XXVIII (09)	945
secondary field, reactive effect .....	XXVII (08)	1381
single-phase, current losses, calculation .....	XXVIII (09)	587
current losses, exact equation .....	XXVIII (09)	597
Heyland diagram .....	XXIII (04)	440
Heyland diagram, derivation .....	XXIII (04)	435
performance, calculation .....	XXVIII (09)	591
starting torque, calculation .....	XXVII (08)	373
starting torque with phase splitting devices, calculation .....	XXVII (08)	373
theory, analytical .....	XXIII (04)	433
torque equations .....	XXIII (04)	437
vector diagram .....	XXVIII (09)	587
slip meter .....	XXIV (05)	879
relation to torque .....	XXIX (10)	1409
slot leakage, calculation .....	XXIV (05)	660
effect of squirrel cage speed .....	XXIV (05)	684
reactance, formula .....	XXVI (07)	1488
tests .....	XXVI (07)	1496
speed characteristics, compared with synchronous motor .....	XVIII (01)	374
speed-time curves .....	XVIII (01)	616
starting characteristics .....	XVIII (01)	320
characteristics, compared with synchronous motor .....	XVIII (01)	372
current compared with direct current .....	XVIII (01)	320
torque .....	XVIII (01)	428
compared with direct current .....	XVIII (01)	320
stator temperature, effect of high-resistance rotor .....	XXVIII (09)	539
temperature rise in rotor, calculation .....	XXVIII (09)	528
temperature rise, starting, calculation .....	XXVIII (09)	554
temperature rise in stator, calculation .....	XXVIII (09)	529
temperature-loss diagram .....	XXVIII (09)	539
theory, method of teaching .....	XXI (03)	595
tooth-tip leakage, calculation .....	XXIV (05)	663
reactance, formula .....	XXVI (07)	1491
reactance, tests .....	XXVI (07)	1499

Motors, a. c. induction, (*continued*)

torque relation to e. m. f. ....	XXVIII (09)	580
slip .....	XXIX (10)	1409
total leakage, calculation .....	XXIV (05)	672
variable number of poles .....	XXVIII (09)	602
speed, characteristics of		
hoisting plant .....	XXIX (10)	268
vs. direct current .....	XVIII (01)	320
for factory		
drive .....	XVIII (01)	333
weight, compared with direct		
current .....	XVIII (01)	910
windings (see Windings).		
zig-zag leakage, calculation .....	XXIV (05)	663
coefficient, calcu-		
lation .....	XXVI (07)	1521
coefficient, defini-		
tion .....	XXVI (07)	1520
reactance, formula .....	XXVI (07)	1491
reactance, tests .....	XXVI (07)	1499
railway, maximum size for truck suspension .....	XXIII (04)	45
steel mills, first in U. S. ....	XXVIII (09)	103
synchronous characteristics, ideal .....	XXVIII (10)	289
load curves .....	XIX (02)	785
compared with induction		
motor .....	XVIII (01)	372
compounding method .....	XIX (02)	753
construction, compared with		
induction motor .....	XVIII (01)	372
cost compared with induction		
motor .....	XVIII (01)	379
current characteristics com-		
pared with induction motors .....	XVIII (01)	374
design for power-factor regu-		
lation .....	XXIII (04)	481
excitation, effect on trans-		
mission line performance .....	XXIX (10)	352
flywheel effect .....	XXIII (04)	508
instability .....	XXVIII (09)	43
objections .....	XVIII (01)	431
performance characteristics,		
compared with induction		
motor .....	XVIII (01)	425
permissible drop .....	XXIII (04)	785
phase characteristics .....	XIX (02)	783
unbalance, study of		
effects .....	XXVIII (09)	559
power, effect of phase un-		
balance .....	XXVIII (09)	570
power, effect of voltage un-		
balance .....	XXVIII (09)	570
regulating effect on unbalanced		
circuits .....	XXVIII (09)	585
power-factor characteristic		
compared with induction		
motor .....	XVIII (01)	375

Motors, a. c. synchronous (*continued*)

- power-factor characteristic compared with induction motor .....XVIII (01) 375
- power-factor regulation, automatic excitation .....XXIII (04) 509
- power-factor regulation, early use .....XXIII (04) 494
- power-factor regulation, inventor of system .....XXIII (04) 505
- power-factor regulation of long transmission lines.....XXIII (04) 486
- power-factor regulation, method of rating.....XXIII (04) 495
- power-factor regulation, short-circuit limits .....XXIII (04) 485
- power-factor regulation, speed limits .....XXIII (04) 485
- power-factor regulator and motor combined .....XXIII (04) 487
- rating for power-factor regulation .....XXIII (04) 495
- reactions on generator .....XVIII (01) 375
- regulating characteristics, mechanical conditions that affect .....XXIII (04) 483
- regulating power-factor.....XIX (02) 781
- reliability .....XVIII (01) 376
- speed characteristics compared with induction motor.....XVIII (01) 374
- starting characteristics, compared with induction motor.XVIII (01) 372
- voltage unbalance, study of effects .....XXVIII (09) 559
- applications, attaching pinions to standard motors.XXIX (10) 631
- choice for different machine tools...XXIX (10) 628
- group drive, selection of number of machines .....XXIX (10) 167
- vs. individual drive for machine tools .....XXIX (10) 641
- importance of using standard types...XXIX (10) 630
- individual vs. group drive for machine tools .....XXIX (10) 641
- to machine tools, examples.....XXIX (10) 621
- general principles.XXIX (10) 422
- burnouts, causes .....XXIX (10) 422
- control (see Control).
- design, elastic stresses, theory .....XXVII (08) 1059
- d. c. adjustable speed, performance of different types.XX (02) 175
- armatures, method of design.....XXIV (05) 702
- (also see Armatures)
- compound, effect of amount of compounding upon flywheel operation.....XXVII (08) 331
- speed-current curves .....XXVII (08) 323
- speed variation for given change in load .....XXVII (08) 322

Motors, d. c. (*continued*).

cross induction, definition .....	XXVII (08)	157
current consumption, different sizes .....	XVIII (01)	904
double commutator, for printing press drive .....	XX (02)	143
efficiency, different sizes .....	XVIII (01)	904
elevator .....	XIX (02)	469
field strength control with adjustable re-		
luctance .....	XIX (02)	1131
vs. induction .....	XVIII (01)	320
for factory drive .....	XVIII (01)	333
Johnson, adjustable reluctance, magnetism		
distribution .....	XIX (02)	1138
experience with hunting .....	XXIII (04)	345
limiting sizes .....	XXIV (05)	709
actual .....	XXIV (05)	713
performance characteristics, compared with		
induction .....	XVIII (01)	336
compared with induction .....	XVIII (01)	909
railway, acceleration, average loss, calcu-		
lation .....	XXII (03)	670
efficiency, relation to maximum		
speed .....	XXII (03)	665
flash-over tendency, elimination .....	XXIII (04)	386
heat loss determination .....	XXII (03)	672
distribution .....	XXII (03)	672
Hutchinson method of calculating tempera-		
ture rise .....	XXII (03)	661
method of calculating tempera-		
ture rise, limitations .....	XXII (03)	680
losses, average during acceleration, calcu-		
lation .....	XXII (03)	670
temperature rise calculation .....	XXII (03)	661
rating, calculation for given service .....	XXII (03)	661
series, commutating pole, commutator flash-		
ing and creeping		
distance .....	XXVI (07)	1418
diameter of com-		
mutator .....	XXVI (07)	1414
description .....	XXVI (07)	1411
general discussion .....	XXVI (07)	1407
maximum voltage .....	XXVI (07)	1414
potential between		
commutator seg-		
ments .....	XXVI (07)	1414
use .....	XXV (06)	343
commutation troubles in railway ser-		
vice .....	XXVI (07)	1408
commutator flashing and creeping		
distances .....	XXVI (07)	1418
compared with single-phase for rail-		
way work .....	XXVI (07)	787
efficiency .....	XXVI (07)	790
inherent differences from single-phase .....	XXVI (07)	710
merits compared with single-phase		
for railways .....	XXVI (07)	696
output compared with single-phase .....	XXVI (07)	701

Motors, d. c. series, (*continued*)

power-time curves	.....XVIII (01)	615, 616
potential between commutator segments	.....XXVI (07)	1414
speed-current curves	.....XXVII (08)	323
formula	.....XXII (03)	173
empirical equation	.....XXII (03)	138
speed-time, curves	.....XVIII (01)	615, 616
speed-torque characteristics	.....XX (02)	33
speed variation for given change in load	.....XXVII (08)	322
torque-current curve, empirical equation	.....XXII (03)	172
equation	.....XXII (03)	147
weights compared with single-phase	.....XXVI (07)	699, 1378
shunt, commutating pole, advantages	.....XXV (06)	338
commutating pole, excitation relation to speed	.....XXV (06)	334
commutating pole, flux distribution, no load and full load	.....XXV (06)	336
commutation with weakened field	.....XX (02)	172
design factors	.....XXV (06)	329
flux distribution at full load, high speed	.....XXV (06)	330
flux distribution at no-load, high speed	.....XXV (06)	330
speed-current curves	.....XXVII (08)	323
speed variations for given change in load	.....XXVII (08)	322
starting characteristics	.....XVIII (01)	320
steel mills, first in U. S.	.....XXVIII (09)	102
Stow, performance characteristics	.....XIX (02)	1136
variable speed, classification	.....XX (02)	127
operation on three-wire system	.....XX (02)	129
weight compared with induction	.....XVIII (01)	910
elevator a. c. power-time curves, tests	.....XIX (02)	431
Anthony	.....XIX (02)	467
d. c. power-time curves, tests	.....XIX (02)	431
number direct and alternating operated in New York	.....XIX (02)	429
field poles (see Field).		
history of applications in steel mills	.....XXVIII (09)	102
hoist, rating calculation	.....XXIX (10)	323
operation, burnouts, causes	.....XXIX (10)	422
pinions attaching to standard motors	.....XXIX (10)	631
railway (also see name of motor).		
a. c. advantages compared with d. c.	.....XXIII (04)	625
speed-torque, characteristics	.....XXIII (04)	627
vs. d. c. general discussion	.....XXVI (07)	681, 773
calculation of capacity from typical run curves	.....XXIII (04)	709
constant power vs. constant speed	.....XXIV (05)	510



Motors, railway (*continued*)

d. c. acceleration copper losses, equation....XXII	(03)	149
iron losses, equation....XXII	(03)	150
advantages compared with a. c.....XXIII	(04)	625
copper losses.....XIX (02)	158; XXII (03)	283
actual .....	XIX (02)	170
distance-time curves, universal.....XXII	(03)	143
efficiency .....	XIX (02)	158
energy consumption .....	XIX (02)	538
flywheel effect, effect of gear ratio....XIX	(02)	166
heating, relation to square root, mean square current .....	XXII (03)	301
iron loss .....	XIX (02) 158; XXII (03)	286
actual .....	XIX (02)	170
variation with speed.....XIX	(02)	158
load characteristics .....	XXII (03)	281
factors that limit.....XXII	(03)	281
motor curve acceleration energy, equation .....	XXII (03)	148
performance curves .....	XIX (02)	140
rating determination .....	XIX (02)	160
one hour and continuous..XIX (02)	159; XIX (02)	171
schedule speeds for different opera- tion conditions .....	XIX (02)	176
service-capacity curves .....	XIX (02)	817
speed-current curve, general equation.XXII	(03)	138
speed-time curves, universal .....	XXII (03)	143
speed-torque characteristics .....	XXIII (04)	627
starting characteristics .....	XIX (02)	534
temperature measurement during operation .....	XXII (03)	291
temperature rise due to copper losses.XXII	(03)	283
tractive effect current curve, empiri- cal equation .....	XXII (03)	172
gear ratios in practice.....XXIV	(05)	569
heating losses distribution .....	XIX (02)	812
induction air-gap .....	XIX (02)	550
concatenated, energy consump- tion .....	XIX (02)	538
energy consumption.....XIX	(02)	538
starting characteristics, con- catenated .....	XIX (02)	534
starting economy, calculation..XIX	(02)	534
three-phase disadvantages .....	XIX (02)	544
limitations in design.....XXVI	(07)	695
one-hour rating, advantages .....	XIX (02)	824
radiation power .....	XIX (02)	171
rating, relation to service performance....XXII	(03)	102
space economy, effect of mounting.....XXIX	(10)	44
speed control (see Control).		
Motor-generator, cost compared with synchronous con- verters..XVIII (01)	153; XXI (03)	436; XXVI (07)
		309, 313
efficiency .....	XVIII (01) 138, 144; XXVI (07)	674
compared with synchronous converters..XXI (03)	436; XXVI (07)	309,
		316, 322, 329, 334

- Motor-generator, efficiency (*continued*)
- different loads .....XVIII (01) 151
  - induction, advantages over synchronous
    - converters.XVIII (01) 612; XXIV (05) 733
    - cost comparative.....XXVI (07) 309, 313
    - efficiency ..XXVI (07) 309, 316, 322, 329, 334
    - reliability, comparative..XXVI (07) 305, 320, 326, 328, 333, 342, 344, 347
    - starting, ease, comparative...XXVI (07) 310
  - reliability compared with synchronous converters.XXVI (07) 305, 320, 326, 328, 333, 342, 344, 347
  - starting, ease compared with syn-
    - chronous converters .....XXVI (07) 310
  - standard speeds, 25-cycles .....XXIV (05) 718
    - 60-cycles .....XXIV (05) 718
  - synchronous, advantages over synchro-
    - nous converters.....XVIII (01) 611
    - cost .....XXIV (05) 719
    - comparative ..XXVI (07) 309, 313
    - efficiency..XXIV (05) 719; XXVI (07) 309, 316, 322, 329, 334
    - interchange of current
      - between different ma-
        - chines, tests .....XXV (06) 119
      - methods of starting.....XXV (06) 122
      - synchronizing.XXV (06) 122
    - parallel operation, load
      - division, effect of ex-
        - citation .....XXV (06) 135
    - phase displacement rela-
      - tion to angular lag.....XXV (06) 115
    - reliability, comparative....XXVI (07) 305, 320, 326, 328, 333, 342, 344, 347
    - requirements for equal
      - load division .....XXV (06) 116
    - speeds, standards.....XXIV (05) 718
    - starting, ease, compara-
      - tive .....XXVI (07) 310
    - technical data on com-
      - mmercial machines .....XXV (06) 126
    - uses .....XXV (06) 113
  - vs. synchronous converters, relative
    - mints .....XXVI (07) 303
- Motormen, effect on power consumption.....XIX (02) 169
- Mount Whitney Power Co., generating stations.....XXIX (10) 747
  - irrigation-power system....XXIX (10) 737
- Mountain railways, service characteristics.....XXVI (07) 1661
  - transportation (also See transportation).
    - classification .....XVIII (01) 191
- Mules, maximum pull .....XXVII (08) 294
  - mountain transportation .....XVIII (01) 195
  - speed of hauling canal boats.....XXVII (08) 294
- Multi-gap lightning arresters (see lightning arresters).
- Murphy transposition .....XXIII (04) 686
- Mershon formula corona e. m. f.....XXVII (08) 899
- National Board of Fire Underwriters, history of fuse
  - specifications .....XXIV (05) 893

Navy, French, electricity, applications.....	XIX (02)	583
generator room temperature.....	XIX (02)	735
German, electricity, applications.....	XIX (02)	582
relative merits of a. c. and d. c. energy on ships....	XIX (02)	701
Russian, electricity, applications .....	XIX (02)	582
standard e. m. f. ....	XIX (02)	580
U. S. electric signals on warships.....	XIX (02)	610
electrical specifications, criticism of low		
temperature rise .....	XIX (02)	698
history of voltages used.....	XIX (02)	643
motor applications .....	XIX (02)	607
ammunition hoists.....	XIX (02)	608
boat hoists .....	XIX (02)	609
turrets .....	XIX (02)	609
requirements for electric machinery on shore.....	XIX (02)	703
signal telegraphs for warships.....	XIX (02)	614
solenoid whistle for warships.....	XIX (02)	613
specifications, electrical equipment.....	XIX (02)	589
engine-driven generators.....	XIX (02)	590
generators .....	XIX (02)	592
switchboard, standard arrangement.....	XIX (02)	599
wiring .....	XIX (02)	600
wiring rules .....	XIX (02)	603
U. S. S. Alabama, dynamos, construction.....	XIX (02)	583
Chicago, generating equipment.....	XIX (02)	586
Kearsarge, electric distribution system....	XIX (02)	648
Trenton, generating equipment.....	XIX (02)	585
Needle-gap (also see Spark-gap).		
accuracy for e. m. f. measurement.....	XXIV (05)	446
calibration, effect of current limiting devices.....	XXIV (05)	432
grounding .....	XXIV (05)	432
small series gap.....	XXIV (05)	432
with various current limiting		
devices .....	XXIV (05)	427
effect of small series gap on breakdown e.m.f.....	XXIV (05)	432
e. m. f. effect of arcing ground.....	XXV (06)	378
metallic ground .....	XXV (06)	378
oscillations .....	XXV (06)	378
equivalent, effect of natural frequency.....	XXVI (07)	1082
quantity of charge.....	XXVI (07)	1084
rate of charge.....	XXVI (07)	1083
measurement .....	XXV (06)	381
method of determination.....	XXVI (07)	1074
sharpness, effect on sparking distance.....	XXIV (05)	449
use for e. m. f. measurement.....	XXV (06)	373
Nernst glower, intrinsic brilliancy.....	XXVI (07)	628
lamps (see Lamps).		
Neutral currents in star-connected generators, theory....	XXIX (10)	765
grounded (see Grounded).		
New Milford Power Co. transmission plant, description....	XXV (06)	349
York Central delays compared with New Haven....	XXVII (08)	1692
dynamometer car tests.....	XIX (02)	879
electrification, actual savings accom-		
plished .....	XXVI (07)	1676
cost compared with		
New Haven.....	XXVI (07)	808

New York Central (*continued*)

locomotive dimensions compared with		
Vattellina three-phase		
machine . . . . .	xxiv (05)	501
efficiency . . . . .	xxiv (05)	503
signal system in electric zone . . . . .	xxvi (07)	1546
specifications for 11,000 and 650-volt		
strain insulators . . . . .	xxix (10)	1034
Terminal, choice of electric system . . . . .	xix (02)	891
fixed and operating charges,		
various electric systems,		
estimated . . . . .	xix (02)	895
& Chance Mine, Colo., electric equipment . . . . .	xviii (01)	200
Edison Co. all-year efficiency of synchronous		
converters . . . . .	xxvii (08)	243
experience, high-tension cables . . . . .	xxii (03)	422, 433
record of cable troubles . . . . .	xxvii (08)	1554
New Haven & Hartford catenary construction . . . . .	xxix (10)	998
delays compared with		
New York Central . . . . .	xxvii (08)	1692
fuel consumption,		
steam locomotives . . . . .	xxvi (07)	146
locomotives, log of		
mileage . . . . .	xxvii (08)	1653
locomotives, log of		
repairs . . . . .	xxvii (08)	1649
locomotives, log of		
trailing loads . . . . .	xxvii (08)	1655
log of delays . . . . .	xxvii (08)	1640
operation . . . . .	xxvii (08)	1613
pioneer features . . . . .	xxvii (08)	1656
repairs and main-		
tenance charges for		
steam locomotives . . . . .	xxvi (07)	112
voltage drop, actual . . . . .	xxix (10)	15
Subway, weights, loaded cars . . . . .	xxiii (04)	694
Niagara Falls, alternators, first, mechanical features . . . . .	xviii (01)	459
circuit diagram of transmission system . . . . .	xviii (01)	484
development, reasons for adopting 25		
cycles . . . . .	xviii (01)	451
reason for adopting 2,000		
volts . . . . .	xviii (01)	453
report to Cataract Con-		
struction Co. . . . .	xviii (01)	447
estimated power . . . . .	xxvii (08)	379
experimented high-tension line, descrip-		
tion . . . . .	xxvii (08)	846
ice troubles, preventions . . . . .	xxiv (05)	811
map . . . . .	xxiv (05)	808
Power Co., cable bridge constructions . . . . .	xviii (01)	514
connections, various stations,		
diagram . . . . .	xix (02)	778
customers and loads . . . . .	xviii (01)	505
date of starting first gene-		
rator . . . . .	xviii (01)	478
energy output of plants . . . . .	xxviii (09)	165
external revolving field gen-		
erators, sectional view . . . . .	xix (02)	769

- Niagara Falls Power Co. (*continued*)
- generator efficiency .....XIX (02) 771
  - revolving weight..XVIII (01) 462
  - sectional drawings.XVIII (01) 460
  - ventilation in power
    - house No. 2.....XIX (02) 768
  - internal revolving field gen-
    - erator, sectional view..XIX (02) 770, 777
  - local distribution system.....XVIII (01) 505
  - methods of starting plant....XVIII (01) 542
  - power house No. 1 plan.....XVIII (01) 486
  - No. 2, descrip-
    - tion .....XIX (02) 765
  - transmission line, construc-
    - tion .....XVIII (01) 518
  - underground distribution
    - system .....XVIII (01) 496
  - Lockport & Ont. Pow. Co., cable sizes.....XVI (07) 1296
  - lightning arrester
    - equipment of sub-
      - station .....XXVI (07) 1308
    - spacing of lightning
      - arresters along line.XXVI (07) 1314
    - standard spans.....XXVI (07) 1287
    - transmission plant,
      - description .....XXVI (07) 1273
  - Niagara-Buffalo, transformer house connections.....XVIII (01) 485
  - transmission line, map.....XVIII (01) 836
  - plant .....XVIII (01) 125
  - Nickel electroplating, current density .....XIX (02) 282
  - process .....XIX (02) 282
  - magnetization curve .....XVIII (01) 468
  - temperature coefficient of resistivity .....XXV (06) 475
  - Nickel-steel (see Steel, nickel).
  - Nicholson arcing rings .....XXIX (10) 584
  - (also see Arcing rings).
  - Night schools, field of usefulness .....XXVIII (09) 1101
  - Nitrogen, coefficient expansion, temperature.....XXV (06) 475
  - Non-synchronous generators (see Generators induction).
  - Northern Texas Traction Co., service tests .....XXII (03) 223
  - Northrup hot-wire comparator .....XXIV (05) 742
  - Oechelhauser gas engine, description .....XVIII (01) 88
  - Ohm, relation to c. g. s. unit.....XXII (03) 531
  - Oils, burning temperatures .....XXIX (10) 1190
  - carbonized, dielectric strength compared with new
    - oil .....XXIX (10) 1098
    - resistivity compared with new oil.....XXIX (10) 1098
  - characteristics as cooling agent.....XXVI (07) 839
  - cotton-seed conductivity, thermal.....XXIV (05) 403
  - dielectric strength, effect of moisture .....XXIX (10) 1198
  - temperature .....XXIX (10) 119
  - various shaped electrodes.....XXIX (10) 1195
  - disruptive energy .....XXIX (10) 1151
  - drying, centrifugal method .....XXIX (10) 1203
  - chemical methods .....XXIX (10) 1200
  - heat methods .....XXIX (10) 1202

Oils, (*continued*)

methods, relative merits .....	XXIX (10)	1200
paper filter .....	XXIX (10)	1204
fires, extinguishing with steam .....	XXIII (04)	188
flashing temperature .....	XXIX (10)	1190
insulation resistance, effect of temperature.....	XXIX (10)	1206
linseed, conductivity, thermal .....	XXIV (05)	403
non-freezing .....	XXVIII (09)	244
paraffin, dielectric strength, transient e. m. f.....	XXIX (10)	1132
specific gravity .....	XXIX (10)	1190
striking distance, infinite transient e. m. f.....	XXIX (10)	1143
switch, chemical composition, required.....	XXIII (04)	221
fire test, required .....	XXIII (04)	221
flash point, required .....	XXIII (04)	221
specific-gravity required .....	XXIII (04)	221
switches (see Switches) .....	XXIX (10)	
tests for paraffin .....	XXIX (10)	1205
sulphur .....	XXIX (10)	1205
transformer, as fire extinguisher .....	XXIII (04)	179
burning temperature .....	XXIII (04)	178
explosive pressure .....	XXIII (04)	178
fire risk .....	XXIII (04)	178
flash point, minimum .....	XXIII (04)	184
properties .....	XXIX (10)	1190
testing .....	XXIX (10)	1205
viscosity .....	XXIX (10)	1190
Ontario Power Co., transmission system, line troubles.....	XXIX (10)	576
Ore handling equipment of Gary plant.....	XXVIII (09)	118
machine, braking .....	XX (02)	297
motors, speed control .....	XXVIII (09)	903
power requirements .....	XXVIII (09)	118
unloaders, power requirements .....	XXVIII (09)	117, 157
speed control system .....	XXVIII (09)	943
Organic products, electrolytic production.....	XIX (02)	288
Orsat, flue gas analyses, description .....	XXVI (07)	1773
Oscillations, free, equations .....	XXVII (08)	1278
generation, methods .....	XXVII (08)	564
produced by rupture of arc short-circuit.....	XVIII (01)	386
typical .....	XXVI (07)	418
Oscillograph, Blondel, description .....	XXIV (05)	195
schematic diagram .....	XXIII (04)	406
Duddell, description .....	XXIV (05)	197
errors .....	XXVII (08)	248
first use on high tension lines .....	XVIII (01)	442
General Electric, description .....	XXIV (05)	197
natural period .....	XXIV (05)	205
sensibility .....	XXIV (05)	205
limitations .....	XXVII (08)	1526, 1548
natural frequency maximum .....	XXV (06)	447
silver vs. phosphor-bronze vibrating strips.....	XXIV (05)	205
use in detecting arcing ground .....	XXVII (08)	1557
Osmium filaments (see Filaments).		
lamp (see Lamps).		
resistivity temperature, coefficient.....	XXV (06)	822
Owens, curve tracer, description .....	XIX (02)	1123
Oxy-hydrogen, limelight, original .....	XIX (02)	82
Ozite, conductivity, thermal .....	XXIV (05)	403

Ozokerite, dielectric strength .....	xxv (06)	874
insulating properties .....	xxv (06)	873
melting point .....	xxv (06)	874
solvent .....	xxv (06)	876
Ozone, effect on rubber .....	xviii (01)	535
electrolytic production .....	xix (02)	287
Pacific Gas and Electric Co., record of service inter-		
ruptions .....	xxviii (09)	1420
transmission plant, de-		
scription .....	xxix (10)	706
Light and Power Co., data on 20,000 volt		
generators .....	xxvi (07)	376
Paper, dielectric strength, effect of duration of stress		
application .....	xxvi (07)	1187
Para rubber, definition .....	xix (02)	693
Paraffin oil, dielectric strength, transient e. m. f. ....	xxix (10)	1132
Parallel operation, angular deviation of engine, measure-		
ment .....	xviii (01)	777
displacement for given cross		
current .....	xviii (01)	760
displacement measur-		
ment .....	xviii (01)	719, 788
variation, measurement. ....	xviii (01)	799; xix
	(02)	1128
variation, steam engines,		
mathematical study. ....	xviii (01)	793
variation steam engine, meas-		
urement .....	xviii (01)	720
variation tests of tandem com-		
pound engine .....	xviii (01)	725
anti-surfing device .....	xviii (01)	747
difficulties, causes with independent		
prime movers .....	xviii (01)	742
method of over-coming. ....	xviii (01)	747
division of load, relation to speed char-		
acteristic .....	xviii (01)	789
effect of speed change due to change		
of load .....	xviii (01)	741
regulation character-		
istics .....	xviii (01)	741
flywheel capacity, calculation ....	xviii (01)	763, 772
gas engine-driven-generators .....	xxix (10)	444
gas-engine, speed specifications in		
Europe .....	xxv (06)	51
generators a. c. singular displacement,		
standard .....	xxiii (04)	353
flywheel effect equa-		
tion .....	xviii (01)	798
fundamental difficulty. ....	xviii (01)	782
permissible angular		
velocity variations. ....	xxiii (04)	272
requirements .....	xviii (01)	775
stable division of load. ....	xviii (01)	788
surging, causes .....	xviii (01)	776
armature reaction effect of		
divisions of load. ....	xviii (01)	755
principles .....	xviii (01)	753

- Parallel operation, (*continued*)
- hydroelectric plants, advantages.....xxix (10) 548
    - general discussion.....xxix (10) 547
    - speed regulation.....xxix (10) 570
  - mercury vapor converters .....xxv (06) 620
  - requirements of engine governor.....xviii (01) 773
  - star-connected generators on grounded
    - system .....xxix (10) 765
  - synchronous converters .....xxiv (05) 736
    - grounded
      - neutral .....xxiii (04) 350
  - machines, circle diagram.....xxvi (07) 1028
    - efficiency
      - formula .....xxvi (07) 1038
    - power input
      - equation .....xxvi (07) 1035
    - power output
      - formula .....xxvi (07) 1034
  - motor-generators, analysis.....xxv (06) 113
  - motor-generators, effect
    - of excitation on load
      - division .....xxv (06) 135
  - motor-generators, re-
    - quirements for equal
      - load division .....xxv (06) 116
  - motor-generators, syn-
    - chronizing .....xxv (06) 122
  - synchronizing power formula .....xxvi (07) 1043
  - transformers .....xviii (01) 850
  - transmission lines .....xxiii (04) 547
    - automatic sectional-
      - ization .....xxix (10) 617
- Parsons steam turbine (see Turbine).
- Patent claims in U. S. constitution .....xxviii (09) 321
- discrimination against foreigners, advisability.....xxviii (09) 331
  - first in America .....xxviii (09) 312
    - recorded .....xxviii (09) 318
  - system, beginning .....xxviii (09) 315
    - English statute of Monopolies.....xxviii (09) 320
    - Great Britain compared with U. S.....xxviii (09) 322
    - history of development .....xxviii (09) 315
    - inventor's view point .....xxviii (09) 339
    - protection to community .....xxviii (09) 329
    - relation to industrial development.....xxviii (09) 315
    - U. S. compared with Great Britain.....xxviii (09) 322
      - relation to actual affairs.....xxviii (09) 324
- Pearson-Cutcheon static discharger, connection diagram.....xxiv (05) 959
- static by-pass for transformer windings.....xxiii (04) 568
- Pelton wheel (see Turbines).
- Pender's a. c. circuit formulas.....xxvii (08) 1397
- Penstocks, high-pressure, construction, types.....xxii (03) 647
- pressure required to retard water, calculation.....xxv (06) 166
    - rise behind closing valve, calculation.....xxv (06) 167
    - wave, calculation .....xxv (06) 168
  - time constant, calculation.....xxv (06) 168



- Penstocks, (*continued*)
- velocities .....XXIV (05) 812
  - standard .....XXV (06) 156
  - water hammer, protection .....XXII (03) 631
  - prevention.....XXIV (05) 815; XXVI (07) 183
- Pentane lamp (see Light standards).
- Permeability, measurement of large field rings.....XVIII (01) 464
- Phantom transposition .....XXIII (04) 679
- Phase meter (see Meter).
- shifter, description .....XXIX (10) 1536
  - unbalance, effect on power of induction motors...XXVIII (09) 563
  - synchronous motors...XXVIII (09) 570
- Philippine cable (see Cable).
- Phoenix Light and Fuel Co., transmission plant, descrip-  
tion .....XIX (02) 851
- Phono-electric wire (see Wire).
- Phosphorescence, commercial applications.....XXI (03) 338
- definition .....XXI (03) 332
  - in nature .....XXI (03) 340
  - substances .....XXI (03) 333
- Phosphorous, electrolytic production .....XIX (02) 292
- Photographone, Ruhmer's description .....XXI (03) 388
- Photometer, Bunsen, candle-power scale, formula.....XX (02) 78
- electrical connections .....XX (02) 78
  - differential, connections .....XX (02) 84
  - integrating, for incandescent lamps.....XX (02) 61
  - Matthews, incandescent lamps.....XX (02) 61
  - method of smoking
    - glass...XVIII (01) 684
    - using .....XX (02) 61
  - mode of operation...XVIII (01) 681
  - theory .....XX (02) 61
  - working equation...XVIII (01) 686
- Weber, objections .....XX (02) 102
- Photometry, accuracy, commercial .....XX (02) 93
- limits .....XX (02) 87
  - arc lamps .....XVIII (01) 677
  - headlights .....XXIX (10) 1061
  - Hefner lamp, accuracy .....XX (02) 90
  - incandescent lamp standard, accuracy.....XX (02) 92
  - mean horizontal candle-power with Matthews
    - photometer .....XX (02) 65
    - measurements, classification .....XX (02) 88
    - method of comparing different illuminants...XXVI (07) 633
  - Moore tubes .....XXVI (07) 615
  - Pentane lamp, accuracy .....XX (02) 91
  - standards (see Light).
- Physics, instruction from college standpoint .....XIX (02) 1176
- teaching to engineering students .....XXII (03) 561
- Pins, insulator (see Insulator pins).
- Pinch, effect in iron electrodes.....XXIX (10) 511
- Pipe lines (see Penstocks).
- Piping, forced oil, cooling system .....XXVI (07) 836
- Planck's law of radiation .....XXVI (07) 965
- Planers, motors, selection .....XX (02) 211
- Plaster Paris, resistivity, thermal .....XXVI (07) 992

- Platinum, energy reflected at different wave lengths.....XXIX (10) 1723  
     coefficient resistivity, temperature .....XXV (06) 479  
     thermo-e.m.f's. ....XXV (06) 503  
 Platinum-rhodium thermo-e.m.f's. ....XXV (06) 503  
 Plough electric, description .....XVIII (01) 100  
 Point-analysis, vector power .....XXIX (10) 1275  
 Polar diagram vs. clock diagram .....XXI (03) 591  
 Polariphone, characteristics .....XXV (06) 772  
 Poles, bending moment formula.....XXVI (07) 1224  
     cedar, life .....XXIII (04) 584  
     chestnut, life .....XXIII (04) 584  
     concrete, for telegraph lines.....XXIX (10) 1344  
     construction practice .....XXIII (04) 583  
     iron, cost .....XXI (03) 294; XXIII (04) 526,  
         compared with wood, installed.....XXIII (04) 168  
         early history .....XXIII (04) 152  
     juniper, life .....XXIII (04) 584  
     requirements for catenary construction.....XXI (10) 978  
     spacing, catenary construction .....XXIX (10) 981  
     steel, cost .....XXIII (04) 531, 532  
     top construction, spans 500 to 900 feet .....XXVI (07) 1556  
         900 to 3,000 feet.....XXVI (07) 1558  
     high-tension construction practice.....XXIII (04) 601  
     wooden, cost .....XXI (03) 294  
         compared with iron, installed.....XXIII (04) 168  
         disadvantages .....XXIII (04) 512  
         life .....XXIII (04) 511, 524, 544, 610  
         in various parts of U. S.....XXIII (04) 584  
         wet-rot, remedy .....XXI (03) 318  
 Pole-face losses, theory and calculation .....XXVIII (09) 1133  
     winding action .....XXVII (08) 152  
 Pole-lines (see Transmission lines).  
 Polonium discovery .....XXI (03) 344  
     properties .....XXI (03) 344  
 Polyphase, distribution (see Distribution).  
     generators (see Generators).  
     transformers (see Transformers).  
     transmission (see Transmission).  
 Population growth, method of study.....XXVI (07) 570  
 Porcelain, compressive strength .....XXIX (10) 1023  
     manufacture, limitations .....XXIX (10) 1029  
     resistance, ohmic .....XXVII (08) 927  
     shearing strength .....XXIX (10) 968  
     simultaneous electrical and mechanical stresses.XXIX (10) 972  
     tensile strength .....XXIX (10) 968, 1023  
 Porous cup, resistance measurement .....XIX (02) 322  
 Potassium chlorate, electrolytic production.....XIX (02) 287  
 Potential transformers (see Transformers shunt).  
 Potentiometer, a. c. description .....XXIX (10) 1535  
     liquid description .....XIX (02) 317  
 Potomac river, maximum flow .....XXV (06) 184  
     water-shed area .....XXV (06) 184  
 Potts synchronizer, description .....XXVI (07) 521  
 Poulsen telephonograph, description .....XVIII (01) 47  
     duplexing .....XVIII (01) 53

Power a. c. measurement, correction factors for series		
transformers .....	xxviii (09)	1010
consumption, air-blast transformer, blowers.....	xxiii (04)	236
arc lamps .....	xviii (01)	877
due to grades in railways.....	xxvi (07)	99
interurban railway service.....	xxiii (03)	216
electric cooking apparatus .....	xxvii (08)	1603
machine tools, formulas, unreliability.....	xxix (10)	639
variation .....	xxix (10)	640
Morse telegraph relays.....	xxvi (07)	546
demand of United States .....	xxvii (08)	381
electric, demand of different industries in U. S.....	xxvii (08)	387
measurement with quadrant electrometer.....	xix (02)	1040
gas, demand of different industries in U. S.....	xxvii (08)	385
high-tension, measurement .....	xxvii (08)	848
comparison of		
methods .....	xxvii (08)	858
measurements, errors due to instrument trans-		
formers .....	xxiv (05)	167
oil, demand of different industries in U. S.....	xxvii (08)	385
reactive, measurement .....	xviii (01)	300
required to haul canal boats, tests.....	xxvii (08)	285
requirements, ammunition hoists .....	xix (02)	682
cotton mill drive .....	xxvii (08)	293
dredge, gold .....	xxii (03)	512
suction .....	xxix (10)	366
elevators .....	xix (02)	431
department store ser-		
vice .....	xix (02)	484
hoist, coal .....	xx (02)	139
mine .....	xxii (03)	555
irrigation pumping .....	xxix (10)	742
locomotive, contractors .....	xxix (10)	368
machine tools .....	xx (02)	206
machines, various (see Name of machine).		
pumps, centrifugal .....	xxii (03)	514
variable con-		
ditions .....	xxii (03)	650
irrigation .....	xxix (10)	742
railway, city service.....	xviii (01)	589;
xxiii (04)		629
elevated .....	xviii (01)	591
freight service .....	xxvi (07)	76
fast .....	xxix (10)	1424
trunk line.....	xxiii (04)	630
high-speed, level .....	xviii (01)	642
passenger ser-		
vice .....	xxix (10)	1424
interurban service.....	xxii (03)	216; xxiii
(04)		629
freight service.....	xxiii (04)	93
high-speed .....	xviii (01)	592
passenger ser-		
vice .....	xxiii (04)	93

Power requirements, railways, (*continued*)

medium speed, grades and		
curves	..XVIII (01)	642
level	.....XVIII (01)	642
mountain service	.....XXIII (04)	631
passenger service	.....XXVI (07)	73
trunk		
line	..XXIII (04)	630
rapid transit service	.....XXIII (04)	629
slow freight service	.....XXIX (10)	1422
steam	.....XXIII (04)	738
suburban service	.....XXIII (04)	629
switching service	.....XXIX (10)	1422
trunk line	.....XVIII (01)	625
underground	.....XVIII (01)	591
various train services	.....XXIV (05)	529
searchlights	.....XIX (02)	628
shears, large	.....XXVII (08)	321
shovels, electric	.....XXIX (10)	367
telephones	.....XIX (02)	449
textile mills	.....XXIX (10)	388
tunneling	.....XXIX (10)	367
steam, demand of different industries in U. S.	...XXVII (08)	383
vector	.....XXIX (10)	1233
representation	.....XXI (03) 596; XXIX (10)	1250
water (also see Water power).		
demand of different industries in U. S.	...XXVII (08)	384
Power-factor, arc, a. c. enclosed	.....XVIII (01)	559
carbon, enclosed	.....XXIV (05)	882
open	.....XXIV (05)	883
control with synchronous motors	.....XIX (02)	781
elevators	.....XIX (02)	432
measurement with three-phase wattmeter	...XXVII (08)	809
two wattmeters	.....XXVII (08)	815
meter, (see Meters).		
Moore tube lamps	.....XXVI (07)	621, 656
Nernst lamp	.....XVIII (01)	559
regulation, early use of synchronous motors	...XXIII (04)	494
physical analysis	.....XXIII (04)	502
with automatic synchronous		
motors	.....XXIII (04)	509
synchronous converters	...XXIII (04)	488
motors	.....XXIII (04)	481
steel mills, value of control	.....XXVIII (09)	927
three-phase formula	.....XXVII (08)	801
measurement, with wattmeter	...XVIII (01)	299
motor induction, different sizes	.....XVIII (01)	906
in terms of design con-		
stants	.....XXIV (05)	650
railway	...XVIII (01) 614; XXIV (05)	546
repulsion	.....XXIII (04)	2
series	.....XXVII (08)	33
compensated	.....XX (02)	25
railway	.....XXVII (08)	33
rectifier, constant-current mercury	.....XXIV (05)	378

- Power-plants, central (also see Central stations).
- centralization advantages .....XXVIII (09) 355
  - choice and arrangement of apparatus.....XXV (06) 559
  - city, choice of site .....XVIII (01) 814
    - double-current generator value .....XVIII (01) 823
  - connection, system classification .....XXV (06) 581
  - construction, permanent vs. short-lived.XXIX (10) 756, 761
  - cost of construction in California, actual...XXIX (10) 362
    - energy production, estimation .....XXIX (10) 116
  - decentralized (also see Decentralized plants).
    - definition .....XXIX (10) 153
  - economies .....XXV (06) 1
  - economy of centralization .....XXVIII (09) 166
    - due to centralization .....XXIX (10) 110
  - efficiency, effect of accurate instruments....XXV (06) 28
    - thermal .....XXVIII (09) 51
  - Electrical Development Co. ....XXIV (05) 808
  - fixed charges, effect of load-factor.....XXV (06) 25
  - gas combined with gas plant financial
    - analysis .....XXII (03) 783
  - gas-electric, cost .....XXII (03) 794; XXIX (10) 690
  - gas-engine, cost, energy, production.....XXVIII (09) 1484
    - estimated .....XXVII (08) 1131
      - in Europe .....XXV (06) 52
  - daily log large plant .....XXIX (10) 441
  - delays, records .....XXII (03) 770
  - economy .....XXII (03) 778
    - in Europe .....XXV (06) 51
  - efficiency, various plants.....XXII (03) 768
  - equipment, various plants .....XXII (03) 768
  - fixed charges, estimated .....XXVII (08) 1131
  - fuel, cost, actual .....XXII (03) 777
    - economy at various loads..XXVII (08) 1126
  - maintenance charges.....XXIX (10) 239
    - distribution...XXV (06) 26; XXVIII (09) 1480
  - operation charges .....XXVII (08) 1131
    - distribution...XXV (06) 26; XXVIII (09) 1480
    - cost .....XXII (03) 778, 781
      - actual .....XXIX (10) 445
      - Germany .....XXV (06) 38
  - overall efficiency, determination.XXVII (08) 1128
  - producer, advantage of large
    - holders .....XXIX (10) 450
    - fuel consumption...XXIX (10) 446
    - plant losses, analysis.XXV (06) 21
  - Richmond plant, American
    - Locomotive Co. ....XXVII (08) 1123
    - service tests, results .....XXVII (08) 1125
    - typical in Germany .....XXV (06) 49
    - vs. steam turbine, comparative
      - cost and efficiency .....XXVII (08) 1133
  - gas-engine-steam-turbine, cost, energy pro-
    - duction .....XXVIII (09) 1485
  - gas-engine-steam-turbine maintenance
    - charges distribution .....XXV (06) 26

Power-plants, (*continued*)

- gas-engine-steam-turbine, operation charges,
  - distribution .....xxv (06) 26; xxviii (09) 1480
- hydroelectric
  - capitalization of enterprise..xxviii (09) 1412
  - competition with steam.....xxiii (04) 788
  - construction cost, actual.....xxv (06) 186
    - for mines.....xviii (01) 193
  - cost, electric repairs.....xviii (01) 658
  - energy production.....xxviii (09) 1486
    - relative, of different
      - parts of equipment..xxviii (09) 1396
  - customers, classification ....xxviii (09) 1374
  - depreciation, calculation.....xxviii (09) 1424
    - charges..xxviii (09) 1377, 1394
  - development, cost in New
    - England ..xxviii (09) 1406
  - cost, southeast-
    - ern states..xxviii (09) 1453
  - general com-
    - ments .....xxviii (09) 1361
    - outline .....xxvi (07) 179
  - efficiency .....xxii (03) 646
  - energy rates .....xxviii (09) 1372
  - equipment, depreciation.....xxviii (09) 1397
    - for mine service.xviii (01) 194
  - fixed charges .....xxviii (09) 94, 1399
  - flumes (see Flumes).
  - freight haulage as night load.xxix (10) 567
  - general remarks .....xxv (06) 145
  - interruptions, penalties.....xxviii (09) 1370
    - prevention ..xxviii (09) 1367
    - record, Pacific
      - Gas & Elec-
        - tric Co....xxviii (09) 1420
  - load-factor, effect on possi-
    - bilities of competition with
      - steam .....xxiii (04) 783
  - maintenance charges distri-
    - bution .....xxviii (09) 1480
  - Mount Whitney Power Co...xxix (10) 747
  - operation charges, distri-
    - bution .....xxviii (09) 1480
    - cost, actual .....xxv (06) 186
      - effect of
        - load-factor.xxv (06) 141
    - general com-
      - ments .....xxviii (09) 1361
    - with induction
      - generators ...xxvii (08) 240
  - parallel operation advantages.xxix (10) 548
    - general dis-
      - cussion ..xxix (10) 547
  - prices for energy in New
    - England .....xxix (10) 123
  - relation generator, rating to
    - wheel rating .....xxv (06) 159
    - to irrigation..xxviii (09) 1435, 1471

Power-plants, hydroelectric, (*continued*)

secondary power cost.....	XXVII (08)	838
securities, value .....	XXVIII (09)	1361
standby equipment, choice.....	XXVIII (09)	1472
gas engine general		
specifications .....	XXIX (10)	676
service .....	XXVIII (09)	1368
service, choice.....	XXIX (10)	698
service comparative		
cost gas engine		
and steam turbine.....	XXIX (10)	679
service, merits of		
gas and steam.....	XXVIII (09)	1414
steam, economics.....	XXVIII (09)	1380
energy cost.....	XXVIII (09)	1381
service, storage bat-		
tery, cost of		
operation .....	XXVIII (09)	1417
steam turbine, gen-		
eral specifications.....	XXIX (10)	678
storage battery.....	XXVIII (09)	1451
storage of energy as heat.....	XXVII (08)	1600
Illinois Steel Co., South Chicago.....	XXIV (05)	55
industrial, economy incident to centraliza-		
tion .....	XXIX (10)	110
Interborough Rapid Transit Co., N. Y.		
description .....	XXIX (10)	183
isolated, (also see Isolated plants).		
lighting, load-factor .....	XXIII (04)	786
limiting size .....	XXIV (05)	269
location .....	XXIV (05)	29
losses, distribution .....	XXVI (07)	677
maximum room temperatures .....	XXIX (02)	699
parallel vs. independent operation of units.....	XXI (03)	425
oil switches (see Switches).		
railway d. c., cost .....	XXIV (05)	538
load-factor .....	XXIII (04)	786
three-phase, cost .....	XXIV (05)	538
records importance of keeping .....	XXIX (10)	355
reliability insurance .....	XXVIII (09)	65
regulation (see Regulation).		
reliability, methods of maintaining.....	XXIX (10)	357
reserve apparatus .....	XXIV (05)	278
economic usefulness.....	XXIV (05)	261
space distribution among various apparatus.....	XXI (03)	437
required by various prime movers		
(see name of machine).		
steam, auxiliaries, steam vs. electric driven.....	XXV (06)	44
boilers (see Boilers).		
competition with water.....	XXIII (04)	788
cost .....	XXII (03)	794
in New England.....	XXVIII (09)	1407
of energy production.....	XXVIII (09)	1481;
XXIX (10)	117	
fuel, ratio to total.....	XXII (03)	503
economy .....	XXII (03)	778
of large stations.....	XXIX (10)	345

Power-plants, steam, (*continued*)

- effect of exhaust heat on cost of
  - electric energy .....XXIX (10) 121
- fixed charges .....XXVIII (09) 1399
- fuel consumption.....XXII (03) 492, 498
- friction losses .....XXII (03) 496
- high vs. low pressure turbines.....XXIX (10) 232
- load-factor, effect on possibilities of
  - competition with water.....XXIII (04) 783
- losses, analysis .....XXV (06) 3
- maintenance charges, distribution.....XXV (06) 26;
  - XXVIII (09) 1480
- cost .....XXV (06) 34
- operation charges, distribution.....XXV (06) 26;
  - XXVIII (09) 1480
- cost.....XXII (03) 778; XXV (06) 34
  - effect of load-factor...XXV (06) 140
  - Germany .....XXV (06) 38
- saving due to exhaust turbine.....XXIX (10) 244
- specific consumption .....XXI (03) 410
- thermal efficiency .....XXII (03) 497
- turbine, cost of energy production.XXVIII (09) 1482
  - double-deck, actual cost...XXVII (08) 1117, 1119
  - advantages ....XXVII (08) 1100
  - foundations ...XXVII (08) 1103
- maintenance charges, distribution.....XXV (06) 26; XXVIII (09) 1480
- operation charges, distribution.....XXV (06) 26; XXVIII (09) 1480
- West Point double-deck
  - plant .....XXVII (08) 1103
- turbine-driven auxiliaries, advantages .....XXIX (10) 344
- steam-engine-exhaust-turbine, cost energy
  - production .....XXVIII (09) 1483
- steam-engine-exhaust-turbine, effect of
  - superheat on economy.....XXIX (10) 246
- steam-engine-exhaust-turbine, maintenance
  - charges, distribution.....XXV (06) 26; XXVIII (09) 1480
- steam-engine-exhaust-turbine, operation
  - charges, distribution.....XXV (06) 26; XXVIII (09) 1480
- steam-engine-exhaust-turbine, testing layout .....XXIX (10) 221
- steam-engine-exhaust-turbine, tests, 15,000-kw. unit .....XXIX (10) 190
- steam-turbine-gas-engine, cost of energy
  - production .....XXVIII (09) 1485
- steam-turbine-gas-engine, maintenance
  - charges, distribution .....XXVIII (09) 1480
- switches (see Switches).
- temperature records of electrical machines,
  - advantages .....XXIX (10) 350
- wiring (see Wiring).
- Presumpscot Electric Co., lightning experience record.....XXVII (08) 446
  - map of system.....XXVII (08) 443



Preventive leads, definition .....	xxvii	(08)	142
design for single-phase motors.....	xxvii	(08)	143
Prices, hydroelectric energy, New England.....	xxix	(10)	123
Prime movers, aggregate in U. S.....	xxviii	(09)	168
characteristics .....	xxviii	(09)	63
cost of operation as affected by load			
curve .....	xxviii	(09)	1494
cost of operation as affected by load-			
factor .....	xxviii	(09)	1494
economics, ideal .....	xxviii	(09)	63
hydraulic, characteristics .....	xxviii	(09)	72
Interborough Rapid Transit Co., plan and			
elevation .....	xxix	(10)	226
limitations .....	xxviii	(09)	63
maintenance charges, distribution.....	xxviii	(09)	1480
operation charges, distribution.....	xxviii	(09)	1480
thermodynamic, efficiency, .....	xxviii	(09)	73
Printing press, double commutator motor drive.....	xx	(02)	143
Hoe, motor drive .....	xx	(02)	136
speed regulation with storage battery.....	xx	(02)	136
Producers, gas (see Gas producer).			
Property loss by fire in U. S.....	xxvii	(08)	467
Public service commission (see Public utility commission).			
Corp. of N. J., cable system, description....	xxvii	(08)	1542
securities value, effect of central energy			
supply .....	xxviii	(09)	356
utility commissions, personnel, choice.....	xxvii	(08)	350,
354, 357, 363, 366			
purpose .....	xxvii	(08)	340
Pueblo & Suburban Light & Power Co., lightning tests.....	xxvii	(08)	691
Puluy power-factor meter, mode of operation.....	xviii	(01)	293
Pumps, centrifugal, motor rating, determination.....	xxii	(03)	649
power requirements .....	xxii	(03)	514
power requirements, constant head,			
variable speed .....	xxii	(03)	654
power requirements, constant speed,			
varying head .....	xxii	(03)	650
power requirements, variable speed,			
varying head .....	xxii	(03)	653
Pumping, irrigation (see Irrigation).			
Pyro-conductivity of cement .....	xxvii	(08)	738
Pyro-electrolyte, volt-ampere characteristic.....	xxviii	(09)	44
Pyrometers, resistance, classification.....	xxv	(06)	479
construction .....	xxv	(06)	478
decade bridge indicator.....	xxv	(06)	491
indicators .....	xxv	(06)	487
Kelvin double-bridge indicator....	xxv	(06)	492
permanency of calibration.....	xxv	(06)	477
ratiometer indicator .....	xxv	(06)	495
slide-wire bridge indicator.....	xxv	(06)	487
thermo e. m. f., advantages.....	xxv	(06)	505
Radiation capacity of electric heaters.....	xxvii	(08)	1605
color composition, carbon.....	xxix	(10)	1726
daylight .....	xxix	(10)	1726
tungsten .....	xxix	(10)	1726
energy distribution with temperature and wave			
length .....	xxix	(10)	1721

- Radiation energy distribution with (*continued*)
- wave length, carbon...XXIX (10) 1724
      - osmium...XXIX (10) 1724
      - tungsten...XXIX (10) 1724
    - measurement, difficulties.....XXVII (08) 1332
    - reflected at different wave lengths by
      - copper, silver and platinum.....XXIX (10) 1723
    - germicide action .....XIX (02) 74
    - heat, from wires .....XXVIII (09) 370
    - light, limit of efficiency.....XXV (06) 862
    - luminous efficiency .....XXVI (07) 965
    - Planck's law .....XXVI (07) 965
    - selective, definition .....XXIX (10) 1724
    - excitation, definition .....XXV (06) 862
      - from carbon .....XIX (02) 85
      - platinum .....XXIX (10) 1724
      - relation to electric conductivity.....XXVI (07) 968
      - theory .....XXV (06) 793
      - thermodynamic, idea .....XXV (06) 861
    - Stefan-Boltzmann law .....XXVI (07) 964
  - Radioactivity, apparatus used by Curies.....XXI (03) 352
  - theories .....XXI (03) 362
  - Radiophone, selenium, cell .....XXI (03) 373
  - Radium, apparatus used by Curies.....XXI (03) 352
  - burn, nature .....XIX (02) 73
    - discovery .....XXI (03) 344
    - germicide, action.....XIX (02) 74; XXI (03) 359
    - market price .....XIX (02) 70
    - money value .....XXI (03) 350
    - properties .....XIX (02) 69; XXI (03) 346
    - radiations, classification .....XIX (02) 71
    - radio-activity, effect of temperature.....XIX (02) 72
    - rays, penetration .....XXI (03) 368
  - Radius of gyration, wheels.....XX (02) 260
  - Rail bonds (see Bonds).
  - friction coefficient, dry, wet and sanded.....XX (02) 244
    - loss, a. c. railway.....XX (02) 26
    - mills (see Rolling mills).
    - third (see Third rail).
  - Railways, acceleration required for different classes of
    - service .....XXIV (05) 529
    - American, magnitude compared with European...XIX (02) 543
    - city, power requirements.....XVIII (01) 589
    - subways, power requirements.....XVIII (01) 591
    - classification .....XXVI (07) 1694
    - electric, a. c., early patents.....XX (02) 42
    - electrolysis (see Electrolysis).
      - rail loss .....XX (02) 26
      - single-phase, advantages of 15
        - cycles .....XXVI (07) 1387
      - advantages of 25
          - cycles .....XXVI (07) 1386
        - advantages of low
          - frequency .....XXVI (07) 105
      - Arnold electro-pneu-  
matic system.....XIX (02) 1003
      - choice of, e. m. f....XXIV (05) 116

Railways, electric, a. c., single-phase (*continued*)

- choice of frequency.xxvi (07) 89;  
xxvii (08) 18
- comparison with  
steam service...xxvii (08) 1639
- cost, 25 and 15  
cycles .....xxvi (07) 131
- cost compared with  
d. c.....xxvi (07) 766, 776;  
xxvii (08) 1164
- cost estimate de-  
tailed .....xxiii (04) 98
- drop, actual, New  
Haven system...xxix (10) 15
- effect of frequency on  
generating and distri-  
buting apparatus.xxvi (07) 1381
- effects of steam  
locomotives on  
insulation .....xxvii (08) 1620
- energy consump-  
tion, estimate...xxvii (08) 1159
- field of usefulness.xxvi (07) 768
- first cost .....xxvi (07) 390
- general discussion.xxiii (04) 83
- investment compared with  
direct current..xxiii (04) 98
- limitations .....xxiv (05) 539
- motors (see Motors,  
a. c. commutator).
- operation, cost....xxvi (07) 390
- performance com-  
pared with d. c.  
and three-phase.xxiv (05) 484
- principle .....xxiii (04) 85
- relative merits, 25  
and 15 cycles....xxvi (07) 89
- starting character-  
istics .....xxvii (08) 1161
- use of storage bat-  
tery .....xxvii (08) 992
- vs. direct-current.xxvii (08) 1157
- vs. three-phase for  
trunk lines....xxviii (09) 1322
- Ward Leonard sys-  
tem, advantages..xix (02) 1013;  
xx (02) 157
- Ward Leonard system,  
circuit diagram..xxiii (04) 84
- Ward Leonard sys-  
tem, description...xx (02) 155
- Ward Leonard sys-  
tem, weight effi-  
ciency....xx (02) 167, 174, 188
- Washington, Balti-  
more & Annapolis,  
description .....xx (02) 15

Railways, electric, a. c., single-phase, (*continued*)

- weight of car equip-  
ment for 25 and  
15 cycles.....XXVI (07) 1388
- three-phase, acceleration, maxi-  
mum obtainable...XIX (02) 552
- advantages.....XVIII (01) 594, 597  
XIX (02) 523; XXVIII (09) 1315
- Burgdorf-Thun, de-  
scription .....XIX (02) 507
- compared with d. c. for  
trunk line service.XXIV (05) 525
- cost compared with  
d. c. system..XXIV (05) 472, 508
- cost of installation.XXIV (05) 538
- current-collector,  
10,000 volts .....XIX (02) 517
- development .....XXVIII (09) 1353
- differential concatena-  
tion, speed control.XIX (02) 528
- disadvantages..XIX (02) 523, 544;  
XXVIII (09) 1317
- drop, maximum  
allowed .....XIX (02) 550
- effect of air-gap on  
performance ....XVIII (01) 596
- energy consumption.XIX (02) 538
- energy consumption  
compared with d. c.  
system .....XXIV (05) 473
- energy consumption,  
estimated...XXIV (05) 471, 477
- first commercial ap-  
plication .....XIX (02) 500
- flywheel, effect of  
moving trains..XXVIII (09) 1327
- four-speed, control..XIX (02) 528
- Gornergat, descrip-  
tion .....XIX (02) 502
- Great Northern sys-  
tem, description.XXVIII (09) 1281
- ideal conditions...XVIII (01) 599
- installation cost, es-  
timated .....XXIV (05) 471
- Jungfrau, circuit  
diagram .....XVIII (01) 120
- Jungfrau, descrip-  
tion .....XVIII (01) 115;  
XIX (02) 503
- Jungfrau, regenera-  
tive control.....XVIII (01) 119
- Lecco, Sondrio &  
Chiavenna line..XVIII (01) 102
- losses compared with  
similar d. c. sys-  
tem .....XXIV (05) 473

Railways, electric. a. c., three-phase (*continued*)

overhead construc-		
tion .....	XVIII (01)	110
overhead maintenance,		
cost .....	XXIV (05)	479
objections.....	XVIII (01)	595, 598
performance compared		
with d. c.....	XXIV (05)	507, 531
performance compared		
with d.c. and single-		
phase .....	XXIV (05)	484
performance tests...	XIX (02)	523
performance tests,		
Valtellina line...	XXIV (05)	494
power consumption,		
calculation .....	XVIII (01)	625
power consumption,		
estimated ...	XXIV (05)	471, 477
recuperation, prac-		
tical value .....	XXIV (05)	486
speed, mechanical,		
variation .....	XVIII (01)	657
Stansstad-Engelberg,		
description .....	XIX (02)	504
starting character-		
istics, concatenated		
motors .....	XIX (02)	534
starting economy,		
calculation .....	XIX (02)	534
tests, Burgdorf-		
Thun .....	XIX (02)	520
tests, Grosslichter-		
felde .....	XIX (02)	517
Valtellina, descrip-		
tion .....	XIX (02)	515
vs. single-phase...	XXVIII (09)	1322
wiring plan .....	XXIII (04)	94
acceleration, actual curves.....	XXIII (04)	726
auxiliary motors .....	XXIII (04)	754
choice .....	XIX (02)	821
limitation, tests.....	XXIII (04)	728
values .....	XXIV (05)	558
battery, advantages in service.....	XXII (03)	300
catenary construction (see Catenary).		
choice of system for trunk line service.....	XXIX (10)	19
city service, power requirements.....	XXIII (04)	629
tests .....	XXII (03)	290
coal consumption .....	XIX (02)	850
coasting clock, description of installa-		
tion .....	XXIX (10)	1461
effect on coasting per-		
centage, actual.....	XXIX (10)	1484
Manhattan Elevated, tests.....	XXIX (10)	1482
comparison with steam service.....	XXVII (08)	1639
constant-power vs. constant-speed		
motors .....	XXIV (05)	510

Railways, electric, (*continued*)

cost, comparison New York Central & New Haven systems.....	xxvi (07)	808
current collectors (see Current collectors).		
d. c., 600-volt, construction, cost.....	xxix (10)	9
first cost .....	xxvi (07)	390
maintenance, cost.....	xxix (10) 4,	11
operation, cost.....	xxvi (07)	390;
xxix (10)	11	
power consumption.....	xxix (10)	8
vs. 1,200-volt.....	xxix (10)	3
1,200-volt, advantages .....	xxix (10)	3
compared with 600-volt		
for interurban service.....	xxix (10)	1
construction, cost.....	xxix (10)	9
maintenance, cost.....	xxix (10) 4,	11
operation, cost.....	xxvi (07)	390;
xxix (10)	11	
power consumption.....	xxix (10)	8
savings over 600-volt.....	xxix (10)	14
vs. 600-volt .....	xxix (10)	3
acceleration, copper losses, equation.....	xxii (03)	149
cost compared with single-phase.....	xxvi (07)	766, 776
three-phase.....	xxiv (05)	472, 508
construction .....	xxix (10)	9
installation .....	xxiv (05)	538
maintenance .....	xxix (10)	11
operation .....	xxix (10)	11
current-time curves, method of		
application .....	xxii (03)	157
disadvantages .....	xx (03)	16
efficiency, total plant.....	xxii (03)	500
energy consumption.....	xix (02)	538
energy consumption compared with		
three-phase system.....	xxiv (05)	473
energy consumption, estimate.....	xxvii (08)	1157
feeder requirements .....	xxix (10)	8
interurban, cost estimate detailed.....	xxiii (04)	98
investment compared with single-		
phase .....	xxiii (04)	98
losses compared with similar three-		
phase system .....	xxiv (05)	473
maintenance charges .....	xxix (10)	4
and repairs, cost.....	xxvii (08)	1164
motor characteristics, determina-		
tion for given service.....	xxii (03)	153
curve acceleration, energy		
equation .....	xxii (03)	148
heating, relation to square		
root mean square current.....	xxii (03)	301
losses .....	xix (02)	158
rating .....	xix (02)	171
choice .....	xix (02)	176
determination .....	xix (02)	160
speed-current curves, equa-		
tion .....	xxii (03)	138

Railways, electric, d. c., (*continued*)

one-hour motor rating and continuous .....	XIX (02)	159
performance compared with single-phase and three-phase .....	XXIV (05)	484
compared with three-phase system.....	XXIV (05)	507, 531
power consumption .....	XXIX (10)	8
calculation.....	XVIII (01)	624
schedule speeds, different stops per mile .....	XIX (02)	176
speed-current, empirical formula.....	XXII (03)	173
speed-time curves, method of application .....	XXII (03)	157
starting characteristics.....	XIX (02)	534;
XXVII (08)	1161	
substation equipment for 1,200 and 600 volts .....	XXIX (10)	5
torque-current equation.....	XXII (03)	147
tractive effort current curve, empirical equation .....	XXII (03)	172
wiring plan .....	XXIII (04)	96
distribution system (see Distribution).		
efficiency, distribution system.....	XVIII (01)	899
system .....	XIX (02)	849
transmission from generators to cars.....	XXVI (07)	398
energy consumption, different schedule speeds .....	XIX (02)	828
consumption, limited car service, tests .....	XXII (03)	197
consumption, local car service, tests .....	XXII (03)	196
consumption, interurban service, tests .....	XXII (03)	181
consumption, relation to maximum speed .....	XXII (03)	92
consumption, relation to stops per mile .....	XXII (03)	92
saving due to increase in coasting .....	XXIX (10)	1471
due to rapid acceleration.....	XXIX (10)	1466
due to rapid braking.....	XXIX (10)	1468
due to shortening stops.....	XXIX (10)	1469
equipment repairs, cost, Lackawanna & Wyoming Valley R. R.....	XXVI (07)	60
equipment repairs, cost, Manhattan Elevated .....	XXVI (07)	58
equipment repairs, cost, New York subway .....	XXVI (07)	60
equipment repairs, cost, Niagara, Buffalo & Lockport R. R.....	XXVI (07)	61
equipment repairs, cost, Valtellina line.....	XXVI (07)	61
equipment repairs, cost, Wilkes-Barre & Hazleton R. R.....	XXVI (07)	60
first cost .....	XXVI (07)	390

Railways, electric, (*continued*)

fixed and operating charges compared with steam .....	XIX (02)	898
fixed and operating charges, various systems .....	XIX (02)	895
freight service requirements.....	XXVI (07)	76
friction losses in power plant and distribution .....	XXII (03)	496
gears (see Gears).		
gear ratio, choice .....	XIX (02)	823
importance .....	XIX (02)	823
in use .....	XXIV (05)	569
transmission .....	XXIX (10)	1432
Grosse-Lichterfelde, description.....	XVIII (01)	108
interurban, battery load, tests.....	XXII (03)	256
construction, cost.....	XXIV (05)	1067
converter requirements.....	XXIX (10)	1657,
		1667
electric equipment, repairs, cost .....	XXVI (07)	60, 61
express service, power re- quirements .....	XXIII (04)	93
first cost, different types.....	XXVI (07)	390
freight service, power re- quirements .....	XXIII (04)	93
high-speed, power require- ments .....	XVIII (01)	592
induction motor, advan- tages .....	XVIII (01)	594
light construction, pro- posed .....	XXIV (05)	1069
local service, power re- quirements .....	XXIII (04)	93
narrow-gauge construc- tion, cost .....	XXIV (05)	1072
narrow-gauge equipment, cost .....	XXIV (05)	1072
narrow-gauge, proposed.....	XXIV (05)	1069
operating expense.....	XXIV (05)	1074
operation cost, different types .....	XXVI (07)	390
power consumption, calcu- lation .....	XVIII (01)	624
requirements .....	XXIII (04)	629
relative merits of 600 and 1,200-volt d. c. and 6,600- volt a. c. ....	XXVI (07)	387
speed for different classes of service .....	XXIII (04)	93
value of storage battery in substation.....	XVIII (01)	822
load curve .....	XXV (06)	151
tests .....	XXII (03)	256
losses, electrical, in power plant and distribution .....	XXII (03)	496
Middle West, map.....	XXIV (05)	98
motors (see Motors).		



Railways, electric, motors, (*continued*)

efficiency, relation to maximum speed .....	XXII (03)	665
rating, advantages of one-hour method .....	XIX (02)	824
calculation .....	XXII (03)	661
relation to maximum speed and stops per mile .....	XIX (02)	821
relation to schedule speed and stops per mile .....	XIX (02)	819
relation to service performance .....	XXII (03)	102
space economy by choice of mounting .....	XXIX (10)	44
motor-capacity curves, different schedule speeds.....	XXII (03)	100
different temperature rises.....	XXII (03)	100
multiple-unit, acceleration limitation, tests .....	XXIII (04)	728
operating expense compared with steam .....	XXVII (08)	1166
operation, cost .....	XXVI (07)	390
compared with steam.....	XXVI (07)	46
West Side Elevated.....	XXVI (07)	141
overhead construction, catenary (see Catenary).		
Mayer system.....	XXVI (07)	723
Penna. R. R., tests .....	XXIX (10)	1014
trolley (see Trolley).		
passenger service requirements.....	XXVI (07)	73
pinions, life .....	XXIX (10)	1434
power consumption due to grades.....	XXVI (07)	99
effect of motorman.....	XIX (02)	169
interurban service, tests .....	XXII (03)	216
power-plants (see Power-plants).		
apparatus .....	XVIII (01)	603
rapid transit, energy saving by grades to stations .....	XXIX (10)	1492
schedule speed, relation to maximum speed .....	XXII (03)	96
relation to maximum speed and stops per mile .....	XIX (02)	821
relation to stops per mile .....	XXII (03)	96
service-capacity tests, interurban service .....	XXII (03)	202, 223
signal systems (see Signals).		
single-car operation, cost per mile.....	XXII (03)	106
effect on first cost.....	XXII (03)	104
effect on operation cost .....	XXII (03)	104
operation, cost.....	XXII (03)	106

Railways, electric, (*continued*)

stray-currents (see Stray-currents).	
street, causes of delays.....XXIX (10)	1508
energy consumption, tests.....XXIV (05)	66
four-motor vs. two-motor equip- ments .....XXIV (05)	76, 79
minimum headway.....XXIX (10)	1508
operating cost per seat mile.....XXIV (05)	78
platform labor costs.....XXIV (05)	71
speed, average, over intersec- tions, actual .....XXIX (10)	1515
substation, economical number, calcu- lation .....XXIV (05)	1103
suburban, data for service runs.....XXIII (04)	717
motor calculation from typical run curves.....XXIII (04)	709
service tests .....XXIII (04)	706
system, choice, trunk line service.....XXIX (10)	19
test car, Illinois Univ. ....XXV (06)	507
train capacity, increase, N. Y. C. ter- minal, by use of multiple units.XXXVI (07)	777
movement calculation (see Train movement).	
operation, effect on first cost.....XXII (03)	104
effect on operation cost .....XXII (03)	104
two-car operation, first cost.....XXII (03)	107
operation cost.....XXII (03)	107
Ward Leonard system, advantages.....XXIV (05)	540
limitations.....XXIV (05)	540
electrification, coal saving on Manhattan Elevated .....XXVIII (09)	167
European magnitude compared with American...XIX (02)	543
freight service, power requirements .....XXVI (07)	76
requirements .....XXIX (10)	1422
grades, power consumption .....XXVI (07)	99
high-speed, level, characteristic runs .....XVIII (01)	642
power requirements .....XVIII (01)	642
medium-speed, grades and curves, character- istic runs.....XVIII (01)	642
curves, power re- quirements .....XVIII (01)	642
level, characteristic runs.....XVIII (01)	642
power requirements .....XVIII (01)	642
mountain, choice of motive power .....XXVIII (09)	1353
power requirements .....XXIII (04)	631
service requirements .....XXVI (07)	1661
passenger service, power requirements.....XXVI (07)	73
requirements .....XXIX (10)	1424
power required for different classes of service.XXIV (05)	529
rapid-transit service, power requirements.....XXIII (04)	629
weight passenger load .....XXIII (04)	694
schedule speed, relation to stops per mile.....XIX (02)	819
signal systems (see Signals).	
speed-time curves (see Speed-time curves).	
steam, coal consumption .....XIX (02)	850
comparison with electric service, tests.XXXVII (08)	1639
electrification, average cost.....XXVI (07)	1396

Railways, steam, electrification, (*continued*)

consulting engineer, part played .....	xxvi (07)	1697
cost compared with increased trackage .....	xxvi (07)	1684
general discussion .....	xxvi (07)	1693
problem .....	xxvi (07)	681
for U. S.....	xxvi (07)	31
railroad construction engineer, attitude.....	xxvi (07)	1699
railroad management attitude .....	xxvi (07)	1698
saving in dead ton-mileage, New York Central.....	xxvi (07)	1676
saving in fixed charges, New York Central.....	xxvi (07)	1676
saving in repairs, New York Central .....	xxvi (07)	1676
saving in time, New York Central .....	xxvi (07)	1676
effect of electrification on traffic.....	xxvi (07)	40
express service, steam consumption, tests .....	xxvi (07)	1681
fixed and operating charges .....	xix (02)	898
freight service, steam consumption, tests.....	xxvi (07)	1681
local service, steam consumption, tests.....	xxvi (07)	1681
operation cost, classification.....	xxvi (07)	49
compared with electric.....	xxvi (07)	46;
xxvii (08)		1166
power required, actual .....	xxiii (04)	738
signal systems (see Signals).		
suburban, speed-time curves, actual.....	xxiii (04)	713
street (also see Railroads, electric street and Rapid Transit).		
suburban, dynamometer tests .....	xix (02)	879
service, characteristics .....	xxii (03)	92
power requirements .....	xxiii (04)	629
speed-time curves, actual.....	xxiii (04)	713
suspended monorail, cars, dimensions.....	xviii (01)	58
cars, weight.....	xviii (01)	61
construction, cost.....	xviii (01)	58
Engen-Langen system.....	xviii (01)	55
switching service requirements .....	xxix (10)	1422
testing, brake testing .....	xx (02)	224
distance measurement .....	xx (02)	225
manual recording apparatus .....	xx (02)	228
track gauge, standard, origin .....	xix (02)	1016
tractive efforts for various classes of service.....	xxiv (05)	529
train resistance (see Train resistance).		
movement calculations (see Train movement).		
speeds for various classes of service.....	xxiv (05)	529
weights for various classes of service.....	xxiv (05)	529
trunk-line freight service, power requirements.....	xxiii (04)	630
ideal equipment .....	xxiii (04)	618
passenger service, power requirements .....	xxiii (04)	630
power consumption calculation.....	xviii (01)	625
U. S., geographical classification .....	xxvi (07)	85

- Railways, (*continued*)  
     vs. inland waterways .....xxviii (09) 176
- Rainfall, Appalachian Mountains .....xxiv (05) 791
- Broad river .....xxiv (05) 797
- Cape Fear river .....xxiv (05) 795
- Catawba river .....xxiv (05) 796
- distribution, relation to run-off .....xxiv (05) 804
- James river .....xxiv (05) 794
- maximum rate of precipitation in U. S. ....xxvii (08) 953
- record rate .....xxi (03) 280
- Roanoke river .....xxiv (05) 794
- Saluda river .....xxiv (05) 797
- Southern Appalachian mountains .....xxiv (05) 890
- Yadkin river .....xxiv (05) 796
- Rain-gauge for testing line insulators, construction.xxvii (08) 948, 954
- Rapid transit, causes of delay in street car operation....xxix (10) 1508
- economy due to increase in percentage  
         coasting .....xxix (10) 1461
- cost of operation West Side Elevated.....xxvi (07) 141
- electric equipment repairs, cost, actual.xxvi (07) 58, 60
- energy saving by grades to stations.....xxix (10) 1492
- methods of studying movements of public.xxix (10) 1497
- minimum headway for street cars.....xxix (10) 1508
- passengers, per cent who stand by pre-  
             ference .....xxix (10) 1506
- speed, average, over intersections, actual..xxix (10) 1515
- Raritan river, maximum flow .....xxv (06) 184
- water-shed area .....xxv (06) 184
- Rateau turbine (see Turbine).
- Rates, energy, hydroelectric .....xxviii (09) 1372
- telegraph, in 1881 .....xxix (10) 1309
- Rays, Becquerel, properties .....xxi (03) 342
- ultra-violet, generation .....xxi (03) 397
- treatment of disease .....xxi (03) 393
- Rayleigh's power-factor meter, mode of operation.....xviii (01) 295
- Reactance, armature conductors, calculation, example....xxiv (05) 777
- leakage, induction motor, calculation .....xxiv (05) 660
- Reactive ammeter .....xviii (01) 301
- power (see Power).
- wattmeter, electrodynameometer type, description..xviii (01) 300
- induction type, description .....xviii (01) 300
- Rectifiers (also see Converter).
- efficiency .....xviii (01) 144
- electrolytic mode of operation .....xix (02) 293
- for telegraph work .....xxix (10) 1315
- Fleming compared with DeForrest wave detector.xxv (06) 775
- mercury vapor (see Converters).
- Rectification properties of mercury arc, first description...xxiv (05) 395
- Recuperation, (see Control regenerative).
- Recuperative braking (see Braking).
- Reflection, effect on illumination calculation.....xx (02) 73
- Regulation, circuits, a. c., storage battery.....xxvii (08) 987
- and split-pole  
         converter ..xxviii (09) 851
- synchronous exciter, advan-  
         tages .....xxvii (08) 1015

Regulation, (*continued*)

diagram, Baum, method of using.....	XIX (02)	759
e. m. f. adjustable reluctance, first patent.....	XIX (02)	1132
lighting circuits, importance.....	XXII (03)	741
force-speed diagrams .....	XXVI (07)	21
gas-engine, four-cycle .....	XXVI (07)	17
specifications in Europe.....	XXV (06)	51
generators, a. c., calculation.....	XXIII (04)	327
Adams method.....	XXIII (04)	324
comparisons m. m. f., e. m. f. and Adams methods with tests.....	XXIII (04)	324
for different power- factors .....	XXI (03)	513
graphical method.....	XXIII (04)	330
zero power-factor.....	XXIII (04)	310
determination from short- circuit characteristic.....	XIX (02)	1111
determination, indirect.....	XIX (02)	1109
effect of design factors.....	XXII (03)	48
on plant operation.....	XXII (03)	59
induction in parallel with synchronous machines.....	XXIX (10)	241
required for induction motors .....	XVIII (01)	381
two-reactance method of determining .....	XIX (02)	1113
calculation .....	XXI (03)	511
Behn-Eschenburg com- pared with Institute methods .....	XXI (03)	500
Behn-Eschenburg method .....	XXI (03)	499
Kappa diagram.....	XXI (03)	513, 579
definition .....	XXI (03)	498
importance of specifying .....	XXI (03)	570
high-tension distribution system fed from several plants .....	XXIX (10)	570
line, effect of line capacity.....	XVIII (01)	365
inductance .....	XVIII (01)	365
power-factor, early use of synchronous motor.....	XXIII (04)	494
physical analysis .....	XXIII (04)	502
synchronous converter .....	XXIII (04)	488
motors .....	XXIII (04)	481
synchronous converter, e. m. f.....	XXVII (08)	186
transformer, calculations, degree of accuracy.....	XXIX (10)	1291
direct measurement .....	XXIX (10)	1282
effect of magnetizing current.....	XXVIII (09)	473
on wave form .....	XVIII (01)	360
formula .....	XXIX (10)	1293
with variable phase displacement.....	XVIII (01)	356
water wheels, parallel-operated plants.....	XXIX (10)	570
turbine, speed .....	XXV (06)	171

- Regulator, automatic switch type, connections.....XXVII (08) 268  
     carbon, for storage battery booster.....XXIV (05) 1089  
         mode of operation .....XXVII (08) 996  
     Elihu Thomson automatic, e. m. f.....XXVII (08) 265  
     induction, feeder control .....XXVII (08) 260  
     instrument transformers, direct measure-  
         ment .....XXIX (10) 1298  
     potential, rheostat type, connections.....XXII (03) 742  
     power-factor automatic synchronous motor...XXIII (04) 509  
     speed, effect of friction on operation.....XXVI (07) 7  
         windage on operation.....XXVI (07) 7  
     synchronous converters, a. c. booster system,  
         advantages .....XXVII (08) 231  
     Tirrill, for control of induction regulator....XXVII (08) 266
- Regenerative control (see Control).
- Relays, adjustment between power station and sub-  
     station .....XXIV (05) 272  
     a. c., railway signal .....XXVI (07) 1541  
     alternator protection .....XXIV (05) 248  
     bellows type, ampere-time curve .....XXIV (05) 256  
         characteristic curve .....XXIV (05) 250  
         experience .....XXIV (05) 276  
     classification .....XXIV (05) 247; XXV (06) 564  
     connection in three-phase distribution system...XXIV (05) 256  
     feeder, protection .....XXIV (05) 255  
     instantaneous, functions .....XXV (06) 574  
     inverse time-limit, ampere-time curve.....XXIV (05) 256  
         characteristic curve .....XXIV (05) 250  
         functions .....XXV (06) 574  
     low-voltage, functions .....XXV (06) 574  
     New York Edison Co., system.....XXIV (05) 271  
     overload, objections .....XXII (03) 427  
     reverse-power, advantages .....XXII (03) 303  
         characteristic curves .....XXII (03) 304  
         first use .....XVIII (01) 502  
         functions .....XXV (06) 574  
         use on railway feeders.....XXII (03) 439  
     synchronous converter, protection .....XXIV (05) 257  
     telegraph, characteristics, test .....XXVIII (09) 1173  
         Morse duplex, current consumption...XXVI (07) 546  
             quadruplex, current  
                 consumption .....XXVI (07) 546  
             resistance, early types.....XXIX (10) 1328  
     telephone, Edison's loud-speaking phone .....XVIII (01) 54  
     time-limit, application on Niagara Falls Power  
         Co. circuits .....XVIII (01) 498  
         disadvantages .....XIX (02) 776  
         general discussion .....XXIV (05) 247
- Reliability insurance, cost analysis .....XXVIII (09) 65
- Rensselaer Polytechnic Institute, date of founding.....XXVI (07) 1432
- Repulsion motors (see Motors).
- Resistance, electric c. g. s. unit, relation to ohm.....XXII (03) 531  
     variation with temperature, law.....XXV (06) 476  
     leads (see Preventive leads).  
     measurement methods .....XXV (06) 487  
         porous-cup .....XIX (02) 322

Resistivity, various materials (see name of material).		
Resistors, concrete, high-tension construction .....	XXVI (07)	1322
for use on 100,000 volts .....	XXVII (08)	854
Resonance current, equation .....	XXIX (03)	410
c. m. f. relation to charging current.....	XVIII (01)	346
rise, formula .....	XVIII (01)	348
electro-mechanical, conditions to prevent.....	XIX (02)	801
definition .....	XIX (02)	791
frequency, capacity and inductance in series...	XXVI (07)	1198
mechanical, flywheel calculation to avoid.....	XXIII (04)	361
revolving body, equation .....	XXVIII (09)	405
natural frequency, synchronous machinery		
calculation .....	XIX (02)	794
Resources, natural, franchise limited vs. perpetual..	XXVII (08)	495, 498
Retardation (see Braking).		
energy saving due to rapid.....	XXIX (10)	1468
mine hoists, calculations.....	XXIX (10)	295
tilting action on trailer cars, tests.....	XXIX (10)	1457
Retinal persistence, value in illumination.....	XIX (02)	7
Reverse-current indicator .....	XXII (03)	306
Reversing key, synchronous, for exact a. c. measurements..	XXIX (10)	1518
Rheostat, liquid, for control three-phase railway motors..	XVIII (01)	106
water, chief requirements.....	XIX (02)	680
electrostatic capacity .....	XXIII (04)	325
Rivers, preservation by forests.....	XXIV (05)	891
River, Broad, drainage area.....	XXIV (05)	797
rainfall .....	XXIV (05)	797
run-off .....	XXIV (05)	797
Cape Fear, run-off .....	XXIV (05)	795
Catawba, drainage area .....	XXIV (05)	796
rainfall .....	XXIV (05)	796
run-off .....	XXIV (05)	796
Chattahoochee, run-off .....	XXIV (05)	799
Housatonic, minimum flow.....	XXV (06)	184
Hudson, minimum flow .....	XXV (06)	184
James, drainage area .....	XXIV (05)	793
rainfall .....	XXIV (05)	794
run-off .....	XXIV (05)	794
Little Tennessee, minimum flow.....	XXV (06)	184
Mississippi, estimated power .....	XXVII (08)	380
maximum flow .....	XXV (08)	184
watershed area .....	XXV (06)	184
Mobile, run-off .....	XXIV (05)	799
Potomac, maximum flow .....	XXV (06)	184
watershed, area .....	XXV (06)	184
Roanoke, drainage area .....	XXIV (05)	794
rainfall .....	XXIV (05)	794
run-off .....	XXIV (05)	794
Saluda, drainage area .....	XXIV (05)	797
rainfall .....	XXIV (05)	797
run-off .....	XXIV (05)	797
Savannah, drainage area.....	XXIV (05)	798
run-off .....	XXIV (05)	798
Yadkin, drainage area .....	XXIV (05)	795
rainfall .....	XXIV (05)	795
run-off .....	XXIV (05)	796

Roanoke river, drainage area.....	xxiv	(05)	794
rainfall .....	xxiv	(05)	794
run-off .....	xxiv	(05)	794
Rochester Railway and Light Co., exhaust steam heating system .....	xxix	(10)	153
Rock river, Wisconsin, flow characteristics.....	xxv	(06)	595
rainfall on drainage area.....	xxv	(06)	598
Rolling mills, diagrams of passes and sections.....	xxviii	(09)	140
electric drive, a. c. vs. d. c.....	xxviii	(09)	886
advantages .....	xxviii	(09)	881
first in U. S.....	xxviii	(09)	881
speed control .....	xxviii	(09)	897
energy diagram for roll pass.....	xxix	(10)	1388
flywheel effect for given service.....	xxviii	(09)	874
high-carbon steel, power requirements.....	xxviii	(09)	889
induction motors, design data.....	xxviii	(09)	131
interaction with flywheel.....	xxix	(10)	1410
induction-motor-flywheel characteristics.....	xxviii	(09)	870
distribution of torque .....	xxix	(10)	1410
selection of fly-wheel.....	xxviii	(09)	933, 939
load curve, typical .....	xxviii	(09)	114
diagram, load-time.....	xxix	(10)	1391
motors (see Motors).			
general requirements .....	xxviii	(09)	879
performance, short method of investigating motor-driven train .....	xxix	(10)	1411
power required for individual passes.....	xxviii	(09)	140
requirements .....	xxviii	(09)	880
reversing mill, advantages.....	xxviii	(09)	885
roll table, first electric in U. S.....	xxviii	(09)	897
speed control .....	xxviii	(09)	906
three-high vs. two-high rolls.....	xxviii	(09)	155
Roofs, concrete, construction .....	xxiv	(05)	59
Rosa wave tracer, description.....	xxiv	(05)	191
Rotating field (see Field).			
Rousseau diagram, construction .....	xviii	(01)	689
Rowland printing telegraph (see Telegraph, printing).			
Royal Polytechnic in Milan, Italy, engineering courses.....	xxvii	(08)	120
Rubber, effect of ozone.....	xviii	(01)	535
insulation characteristics .....	xxv	(06)	193
resinous material in good quality.....	xxv	(06)	199
as index of quality.....	xxv	(06)	195
specification .....	xxv	(06)	199
over-vulcanization, effect .....	xxv	(06)	196
Para, definition .....	xix	(02)	693
properties, effect of chemical composition.....	xxvi	(07)	1013
quality, relation to electrical properties.....	xxv	(06)	221
resistivity, heat .....	xxvi	(07)	982
under-vulcanization, effect .....	xxv	(06)	196
Rubber-Covered Wire Engineers' Assoc., specifications for 30 per cent. compound.....	xxv	(06)	211
Ruhmer flame telephone transmitter.....	xxi	(03)	382
photographone, description .....	xxi	(03)	388
radiophone .....	xxi	(03)	375



Running factor, definition .....	XXII	(03)	229
Run-off, Broad river .....	XXIV	(05)	797
Cape Fear river .....	XXIV	(05)	795
Catawba river .....	XXIV	(05)	796
Chattahoochee river .....	XXIV	(05)	799
James river .....	XXIV	(05)	794
Mobile river .....	XXIV	(05)	799
Roanoke river .....	XXIV	(05)	794
relation to distribution of rainfall.....	XXIV	(05)	804
Salada river .....	XXIV	(05)	797
Savannah river .....	XXIV	(05)	798
Saluda river .....	XXIV	(05)	797
Yadkin river .....	XXIV	(05)	796
Russel's cable-grading formulas.....	XXIX	(10)	1557
Ryan cathode tube wave meter (see Wave meter).			
corona voltmeter, description.....	XXVIII	(09)	801
formula for corona e. m. f. ....	XXVII	(08)	884
Sacramento valley irrigation system .....	XXIX	(10)	732
Sag-span, equation .....	XXIII	(04)	516
St. Johns and St. Louis railway, overhead construction.....	XXIII	(04)	91
Saluda river, drainage area .....	XXIV	(05)	797
rainfall .....	XXIV	(05)	797
run-off .....	XXIV	(05)	797
Salt vapor, electric conduction.....	XXV	(06)	737
Sand, resistivity, thermal .....	XXVI	(07)	992
San Francisco, automatic telephone plant .....	XXIX	(10)	80
description .....	XXIX	(10)	1357
local organization, beginning .....	XXV	(06)	655
San Joaquin valley irrigation system.....	XXIX	(10)	732
Savannah river, drainage area .....	XXIV	(05)	798
run-off .....	XXIV	(05)	798
Sea-coast defenses, definitions .....	XIX	(02)	665
Searchlight, field, description .....	XIX	(02)	718
power requirements .....	XIX	(02)	628
Secondary power, cost .....	XXV	(06)	188
Sectionalization automatic, transmission systems....	XXIX	(10)	720, 722
Securities, public service, effect of central energy supply .....	XXVIII	(09)	356
Selective radiation (see Radiation).			
Selenium, atomic weight .....	XXI	(03)	372
buoy, circuit diagram .....	XXI	(03)	387
mode of operation .....	XXI	(03)	387
cell, buoy, description .....	XXI	(03)	387
Ernest Ruhmer experiments .....	XXI	(03)	375
resistance, variation with light.....	XXI	(03)	377
types .....	XXI	(03)	379
cost .....	XXI	(03)	392
deposits, location .....	XXI	(03)	392
effect of temperature .....	XXI	(03)	373
melting point .....	XXI	(03)	372
specific gravity .....	XXI	(03)	372
use with speaking arc .....	XXI	(03)	374
Series transformer (see Transformer).			
Shaft, flexible, bearings, design .....	XXVIII	(09)	407
for high speed, design.....	XXVIII	(09)	403
Niagara generator, No. 1, physical properties.....	XVIII	(01)	470

- Shallenberger meter, performance as power-factor meter...xviii (01) 305  
 Shapers, motors, selection .....xx (02) 211  
 Shawinigan Water and Power Co., line experience.....xxiv (05)  
     Montreal line, equip-ment .....xxiv (05) 935  
     power-plant equip-ment .....xxiv (05) 935  
     transmission system, record of inter-ruptions .....xxviii (09) 1409  
 Shear, electrostatic, explanation .....xxix (10) 1222  
 Shears, power requirements .....xxvii (08) 321  
 Short-circuit, instantaneous power .....xxix (10) 1117  
 Shovels, electric, power requirements.....xxix (10) 367  
 Shunts, heavy-current non-inductive, construction .....xxix (10) 1537  
     transformers (see Transformers).  
 Sibley College, Cornell University, early history.....xxvi (07) 1434  
     occupations of graduates .....xxvi (07) 1439  
 Siemens dynamometer, performance as power-factor meter .....xviii (01) 301  
 Signal, Boston Elevated, circuit diagram.....xxiv (05) 580  
     classification of systems .....xxvi (07) 1535  
     corps, cable, armor wire, tensile strength.....xix (02) 694  
     specifications .....xix (02) 686  
     repeater, wiring diagram.....xix (02) 637  
     electric, for war-ships .....xix (02) 610  
     legibility, effect of high-power headlights.....xxix (10) 1054  
     number of miles of road protected in U. S.....xxvi (07) 1704  
     railways, lamps .....xxiv (05) 585  
     New York subway, performance record.xxiv (05) 590  
     single-rail North Shore R. R., San Francisco .....xxvi (07) 1541  
     system, Boston elevated...xxvi (07) 1538  
     New York subway.xxvi (07) 1543  
     track circuit for steam roads.....xxvi (07) 1536  
     relay, alternating current.....xxvi (07) 1541  
     system, Long Island R. R. ....xxvi (07) 1545  
     New York Central electric zone.....xxvi (07) 1546  
     West Jersey and Seashore R. R.....xxvi (07) 1546  
 Signs, electric, flashing, life of tungsten lamps.....xxix (10) 945  
     tungsten lamps, performance....xxix (10) 1720  
 Silicides, discovery .....xix (02) 299  
     hydrogen obtainable .....xix (02) 300  
     properties .....xix (02) 299  
 Silico-acetylene, properties .....xix (02) 304  
 Silicon carbide, discovery .....xix (02) 297  
 Silver, electrolytic separation process .....xix (02) 285  
     electroplating process .....xix (02) 282  
     energy reflected at different wave-lengths.....xxix (10) 1723  
 Sine, diagram change with cosine.....xviii (01) 288  
 Sines squared, table .....xviii (01) 679  
 Skin effect in iron wires and cables.....xxvi (07) 567  
 Slack, Ohio bituminous, chemical properties.....xxviii (09) 54  
     heat value .....xxviii (09) 52  
 Youghiogheny gas coal, chemical properties.....xxviii (09) 54

- Sleet, repelling action of high tension.....XVIII (01) 536  
     storms, region in U. S. ....XXVII (08) 935  
 Slip meter .....XXIV (05) 879  
 Slotters, motors, selection .....XX (02) 211  
 Small-pox treatment with red light.....XXI (03) 396  
 Sodium, electrolytic separation process.....XIX (02) 286  
 Soils, resistance, various .....XXVII (08) 723  
 Solids, luminescent characteristics, corpuscular theory.....XXV (06) 851  
     selective radiation .....XXV (06) 793  
 Solutions, characteristics .....XIX (02) 345  
     colloidal (see Colloidal).  
 Sound, natural period of human ear.....XXVIII (09) 1187  
     wave propagation .....XIX (02) 570  
 Southern Pacific R. R., specifications for transmission  
     line crossings .....XXIX (10) 906  
     Power Co., lightning disturbances.....XXVII (08) 787  
 Spark discharge in air, explanation.....XXIX (10) 1227  
     lag .....XXIX (10) 1215  
     tests .....XXV (06) 384  
 Spark-gap (see Needle-gap).  
     brass electrode, volt-ampere characteristic...XXVI (07) 463  
     breakdown e. m. f., effect of field distribution...XXV (06) 441  
     calibration, effect of current limiting devices...XXIV (05) 432  
         grounding .....XXIV (05) 432  
         shape of electrodes.....XXIV (05) 432  
         small series gap.....XXIV (05) 432  
     dangers in dielectric, tests.....XXII (03) 361  
     distance, effect of natural frequency of circuit...XXVI (07) 1082  
         quantity of charge.....XXVI (07) 1084  
         rate of charge.....XXVI (07) 1083  
     effect of points on e. m. f.....XIX (02) 268  
         small series gap on breakdown e.m.f...XXIV (05) 432  
     e. m. f., effect of series resistance at high  
         frequency .....XXVII (08) 677  
         Paschen's law .....XXIII (04) 108  
         rise due to discharge.....XVIII (01) 384  
     equivalent (see Needle-gap).  
     for e. m. f. measurement, tests.....XIX (02) 267  
     limitations for high-tension, measurements...XXIV (05) 424  
     non-arcing, definition .....XXVI (07) 462  
     shielded, construction .....XXV (06) 442  
     voltmeter, precautions to be observed.....XXVII (08) 1525  
 Sparking, commutator (see Commutation).  
 Specific consumption, lamp, acetylene gas.....XX (02) 107  
     arc .....XX (02) 107  
         carbon .....XXV (06) 791  
         enclosed a. c. ....XVIII (01) 559  
         d. c. ....XVIII (01) 559  
         carbon filament .....XX (02) 107  
         graphitized filament.....XXIV (05) 847  
         mercury vapor.....XX (02) 59, 107  
         Moore carbon dioxide.....XXVI (07) 620  
         nitrogen .....XXVI (07) 621  
         Nernst....XVIII (01) 75, 558; XX (02) 107  
         osmium filament.....XVIII (01) 75;  
             XXV (06) 792  
         tantalum filament.....XXV (06) 792, 831

- Specific consumption, lamp, (*continued*)  
     tungsten filament.....xxv (06) 792, 857
- Speed, angular variation, measurement.....xviii (01) 719, 785, 799  
     control (see Control).  
     measurement, railway tests .....xxv (06) 512  
         with stroboscopic fork.....xxvii (08) 644  
     variation, measurement .....xix (02) 1128
- Speed-time curves, coefficients for plotting.....xix (02) 926, 930  
     construction for single-phase equip-  
     ment .....xxvii (08) 1152  
     plotting, Mailloux method.....xix (02) 923
- Spherical reduction factor, direct measurement.....xx (02) 69
- Spider, revolving field, Niagara generator No. 1, physical  
     properties .....xviii (01) 469
- Spindlerfeld railway, overhead construction.....xxiv (05) 103
- Standard apparatus, advantages in using.....xix (02) 699  
     Electric Co., insulator pins, dimensions.....xxi (03) 268  
     oscillograms of wave forms along  
     transmission line .....xxiii (04) 403
- Standardization, effect of centralization of energy supply.xxiv (09) 357  
     report .....xix (02) 1075
- Standby charges, gas engines .....xxix (10) 681  
     steam turbines .....xxix (10) 681  
     equipment for hydroelectric plants, choice.....xxviii (09) 1472  
     service, boilers, heat storage of electric energy.....xxix (10) 678  
         rating required .....xxix (10) 679  
     cost comparison, gas engine and steam  
         turbine plants .....xxix (10) 679  
     gas plant cost .....xxix (10) 679  
     gas-engine, general specifications.....xxix (10) 676  
         time to start .....xxix (10) 680  
     hydroelectric plants .....xxviii (09) 1368  
         choice .....xxix (10) 698  
     relative merits of gas and steam.....xxviii (09) 1414  
     steam-turbine plant, cost.....xxix (10) 679  
         time to start.....xxix (10) 680  
     storage battery, cost of operation.....xxviii (09) 1417  
     turbor-generator plant, general specifica-  
     tions .....xxix (10) 678
- stations, cost gas-engine vs. steam-turbine.....xxix (10) 679  
     operation, gas-engine vs. steam-  
     turbine .....xxix (10) 683  
     gas-engine, time to start .....xxix (10) 680  
         vs. steam-turbine .....xxix (10) 679  
     steam-turbine, time to start.....xxix (10) 680  
         vs. gas-engine .....xxix (10) 679
- Standing wave (see Wave).
- Stanislaus transmission lines, arcing rings.....xxix (10) 615
- Stansstad, three-phase railway, description .....xix (02) 504
- Static, definition .....xxvi (07) 492; xxvii (08) 798  
     discharger, testing method .....xxvi (07) 1073  
     (also see Lightning arresters).
- interrupter, definition .....xix (02) 245  
     location in circuits .....xix (02) 247  
     protective power .....xix (02) 246  
     tests .....xix (02) 259

Statute of Monopolies .....	xxviii (09)	320
Steam adiabatic expansion, work available.....	xxv (06)	55
calorimeter design, low-pressure, separating- throttling type .....	xxix (10)	222
consumption, engine, compound 3,500-h. p.....	xxv (06)	15
and exhaust tur- bine .....	xxv (06)	23
condensing .....	xxi (03)	442
Corliss .....	xxi (03)	410
effect of change in vacuum .....	xxv (06)	16
effect of superheat .....	xxiv (05)	38
plants .....	xxi (03)	410
Sulzer .....	xxi (03)	442
turbine, 5,000-kw .....	xxv (06)	19
Curtis .....	xxi (03)	413
effect of superheat.....	xxi (03) 464; xxv (06) 19	
effect of vacuum .....	xxi (03)	464
energy at different pressures .....	xxv (06)	29
engines (see Engines). plants (see Power plants).		
extinguishing oil fires .....	xxiii (04)	188
flow meters, accuracy .....	xxix (10)	1695, 1707
generator, electric, evaporative efficiency.....	xxvii (08)	664
low-pressure, quality sampler, construction.....	xxix (10)	223
sampler construction .....	xxix (10)	223
quality, low-pressure, sampler construction.....	xxix (10)	223
turbines (see Turbines).		
Steel cast, tool cutting speed.....	xx (02)	124
drawn, elastic limit .....	xxix (10)	989
expansion, temperature coefficient .....	xxix (10)	989
modulus of elasticity .....	xxix (10)	989
tensile strength .....	xxix (10)	989
expansion, temperature coefficient .....	xxiii (04)	514
forged, tool cutting speed .....	xx (02)	124
friction, coefficient on steel .....	xxiv (05)	609
industry, power requirements, magnitude.....	xxviii (09)	929
laminations, thermal conductivity .....	xxviii (09)	533
modulus of elasticity of wire.....	xxiii (04)	514
mills a. c. vs. d. c. motors for auxiliary machinery.....	xxviii (09)	155
cambering machine, power requirements.....	xxviii (09)	128
classification .....	xxviii (09)	921
cost of delays .....	xxviii (09)	898
electric power, advantages .....	xxviii (09)	157
problems .....	xxviii (09)	921
Gary plant, electrical equipment .....	xxviii (09)	101
gas power surplus over that required in process .....	xxviii (09)	156
washing machinery, power require- ments .....	xxviii (09)	115
history of motor applications .....	xxviii (09)	102
hot saws, power requirements .....	xxviii (09)	128
low-pressure turbines, advantages .....	xxviii (09)	926
open-hearth, power requirements .....	xxviii (09)	122
ore unloaders, power requirements .....	xxviii (09)	117

Steel mills, (*continued*)

- pig casting machines, power requirements...XXVIII (09) 122
- power-factor control, advantages .....XXVIII (09) 927
  - savings .....XXVIII (09) 936
  - of load .....XXVIII (09) 161
- power requirements, various types .....XXVIII (09) 922
- pumping plant, power requirements .....XXVIII (09) 115
- repair shops, power requirements .....XXVIII (09) 117
- rolling mills (see Rolling mills).
- straightening presses, power requirements...XXVIII (09) 129
- tables and transfers, power requirements...XXVIII (09) 126
- nickel, elastic limit .....XVIII (01) 479; XXVII (08) 1059
- elongation .....XVIII (01) 479; XXVII (07) 1059
- magnetization curve .....XVIII (01) 468
- tensile strength .....XVIII (01) 479
- ultimate strength .....XXVII (08) 1059
- rolling mill (see Rolling mill).
- transformer, aging tests .....XXVIII (09) 466
  - effect of direction of rolling on iron losses .....XXVIII (09) 462
  - iron-loss tests .....XXVIII (09) 439
  - magnetic properties, different makes.XXVIII (09) 464
  - relation between losses and flux densities in various .....XXVIII (09) 461
- wire, (see Wire).
- Stefan-Boltzmann law of radiation .....XXVI (07) 964
- Stevens Institute of Technology, date of founding.....XXVI (07) 1433
- Stock, watering, justification .....XXVIII (09) 1464
- Stow motor, performance characteristics .....XIX (02) 1136
- Strain insulators (see Insulators).
- Stray currents (also see Electrolysis).
  - effect on grounded a. c. generators.....XXVIII (09) 729
  - protection of cables with asphaltum.XXVII (08) 1522, 1533
  - railway current equation, no return copper.XXVI (07) 250
    - return copper for uniform drop .....XXVI (07) 251
    - several insulated return feeders.XXVI (07) 255
    - single insulated return feeders.XXVI (07) 253
    - uniform return copper .....XXVI (07) 251
  - German Society of Gas and Water Engineers rules .....XXVI (07) 286
  - relation between leakage and number return feeders, insulated negative loss.....XXVI (07) 262
  - relative leakage with various arrangements of return feeders and grounded negative loss.....XXVI (07) 260
  - relative leakage with various arrangements of return feeders and insulated negative loss.....XXVI (07) 261
  - three-wire distribution system, experience .....XXVI (07) 269

- Street lighting, tungsten lamps .....XXIX (10) 934  
     railways (see Rapid transit and railways).
- Stresses, elastic, rotating disks and rings, theory.....XXVII (08) 1059
- Striking distance effect of electrode shape with transient  
     e. m. f. ....XXIX (10) 1155  
     relation to energy of discharge.....XXIX (10) 1149
- Stroboscopic fork, accuracy limits .....XXVII (08) 645  
     definition .....XXVII (08) 631  
     Drysdale type, description .....XXVII (08) 632  
     historical outline .....XXVII (08) 632  
     method of use .....XXVII (08) 642  
     portable type, description .....XXVII (08) 636  
     speed measurement .....XXVII (08) 644  
         range .....XXVII (08) 646  
     temperature error .....XXVII (08) 645
- Strowger automatic telephone system, description (also  
     see Telephone) .....XXIX (10) 56
- Struts, strength formula .....XXVI (07) 1225
- Substation, attendance, cost .....XXVIII (01) 647  
     converter, depreciations .....XXVIII (09) 1398  
         efficiency, relation to load-factor.....XXIX (10) 6  
     economical number, calculation.....XXIV (05) 1103  
     Electrical Development Co., description.....XXIV (05) 821  
     high-tension wiring .....XXVI (07) 857, 865  
         layout for roof.....XXVIII (09) 259  
     lightning protection (see Lightning).
- outdoor .....XXVIII (09) 189  
     favorable conditions .....XXVIII (09) 192
- railway, 600-volt equipment .....XXIX (10) 5  
     1,200-volt equipment .....XXIX (10) 5  
     copper equivalent .....XXIX (10) 5  
     d. c. cost .....XXIV (05) 535  
     effect of number of stations upon  
         annual charges .....XXVII (08) 1211  
         efficiency, relation to load-factor.....XXIX (10) 6  
         feeder copper equivalent.....XXIX (10) 5  
         instrument equipment .....XXII (03) 246  
         interurban battery load, tests.....XXII (03) 256  
         load curves, tests .....XXII (03) 256  
         location, economic .....XXVII (08) 1201  
         power capacity formula .....XXVII (08) 1204  
         storage battery, value .....XXVIII (01) 822  
     synchronous converter, cost .....XXIV (05) 1106  
         difficulties in operation.....XXVIII (01) 541  
         operating expense.....XXVIII (01) 873  
         wiring .....XXVI (07) 860  
             diagram .....XXII (03) 270
- switching, layout 60,000 volts .....XXVI (07) 1351  
     100,000 volts .....XXVI (07) 1354
- transformer (also see Transformers).  
     Buffalo-Niagara Falls .....XVIII (01) 141  
     Buffalo-Niagara Falls electric  
         equipment .....XVIII (01) 523  
     construction, Toronto and  
         Niagara Power Co.....XXVI (07) 856

Substation, transformer (*continued*)

cost indoor, compared with out-		
door .....	XXVIII (09)	262
itemized .....	XXVIII (09)	200
layout 33,000 volts .....	XXVIII (09)	194
60,000 volts .....	XXVI (07)	1351
100,000 volts .....	XXVI (07)	1354
outdoor, cost compared with in-		
door .....	XXVIII (09)	262
itemized .....	XXVIII (09)	200
experience .....	XXVIII (09)	228
grounded wires over-		
head .....	XXVIII (09)	235
layout 33,000 volts .....	XXVIII (09)	196
60,000 volts .....	XXVIII (09)	197
non-freezing oil .....	XXVIII (09)	244
operation .....	XXVIII (09)	202
protection of water		
cooling from frost .....	XXVIII (09)	239
troubles, nature .....	XXI (03)	428
Sulzer engine (see Engine).		
Surges, cable distribution, oscillograms (see also Dis-		
tribution) .....	XXVIII (09)	811
tests .....	XXVIII (09)	809
definition .....	XXVIII (09)	1157
distribution of stress in transformer windings .....	XXV (06)	906
systems, methods of protection .....	XXIV (05)	355
effect of localized inductance .....	XXIV (05)	310
series inductance on potential distribu-		
tion in transformer windings .....	XXV (06)	886
on choke coils .....	XXV (06)	909
e. m. f. rise due to interruption of given current,		
formula .....	XXVI (07)	178
energy .....	XXVI (07)	419
high-frequency, production for test .....	XXVI (07)	1078
high-power, effect of localized inductance .....	XXIV (05)	310
experimental study .....	XXIV (05)	366
frequencies .....	XXIV (05)	311
Manhattan railway, explanation .....	XXIV (05)	363
method of protection .....	XXIV (05)	355
hydraulic analogy .....	XXVIII (09)	1158
penetration distance into transformer winding .....	XXVI (07)	1195
possible sources .....	XXIV (05)	322
protector, aluminium, experimental demonstra-		
tion of action .....	XXVIII (09)	840
aluminium, performance (also see		
Cell) .....	XXVIII (09)	809
protective methods .....	XXVIII (09)	1163
produced by grounded phase, experience .....	XXVII (08)	697
recurrent, artificial production .....	XXVI (07)	1141
reflection by inductance tests .....	XXV (06)	887
tests, Missouri River Power Co. lines .....	XXIV (05)	338
Telluride Power Co. lines .....	XXIV (05)	322
theory .....	XXIV (05)	320
theoretical investigation of high-power .....	XXIV (05)	297



Surging, accumulative, favorable conditions .....	XIX (02)	798
between alternators, causes .....	XVIII (01)	776
Suspension, bifilar, formula .....	XIX (02)	1041
insulators (see Insulators) .....	XXVI (07)	
Susquehanna river, minimum flow .....	XXV (06)	184
Switch, air-break, characteristics .....	XXIII (04)	217
e. m. f. rise on opening .....	XXIII (04)	611, 612
enclosed, characteristics .....	XXIII (04)	218
tube .....	XVIII (01)	413
high-tension, outdoor, construction .....	XXVI (07)	1564, 1566
long, high-tension tests .....	XVIII (01)	415
merits on cable circuits .....	XXIII (04)	245
speed of break .....	XVIII (01)	159
vs. oil .....	XIX (02)	270
for induction motors .....	XXIX (10)	168
automatic telephone, construction .....	XXIX (10)	59, 63, 70
busbar, functions .....	XXV (06)	571
cell, concrete, construction .....	XXIV (05)	60
circuit-breakers (see Circuit-breakers).		
classification .....	XXV (06)	564
contactor type, design features .....	XXVIII (09)	914
control in early Niagara plant .....	XVIII (01)	491
fuse, characteristics .....	XXIII (04)	218
generator, functions .....	XXV (06)	569
group, advantages .....	XXIII (04)	200, 211
cost in Manhattan Railway station .....	XXIII (04)	202
definition .....	XXIII (04)	199
disadvantages .....	XXIII (04)	201, 210, 211
high-tension, electrical properties .....	XIX (02)	219
line, types .....	XXIII (04)	217
outdoor .....	XXVIII (09)	189, 247
construction .....	XXVIII (09)	256
waterproof .....	XXVIII (09)	255
line, functions .....	XXV (06)	571
oil, 5,000 hp., description .....	XVIII (01)	494
analytical discussion .....	XXIX (10)	1091
Bay Counties Power Co., design .....	XXIII (04)	220
behavior on short-circuit .....	XXIX (10)	1110
carbonized oil, dielectric strength .....	XXIX (10)	1098
resistivity .....	XXIX (10)	1098
characteristics .....	XXIII (04)	218
cost .....	XXVI (07)	1571
design, principles .....	XXIX (10)	1111
disadvantages of large volume of oil .....	XXIX (10)	1113
electrically operated, Manhattan Ry. Co. ....	XVIII (01)	411
e. m. f. rise, on opening .....	XXIII (04)	612
electrolytic conduction .....	XXIX (10)	1097
energy capacity, maximum .....	XVIII (01)	409
factor-of-safety relation to volume of oil .....	XXIX (10)	1092
high-pressure oil, operation .....	XXIX (10)	1117
high-tension, construction .....	XXVI (07)	1345
underground, construction .....	XVIII (01)	839
inspection .....	XXIX (10)	1105
interlocking .....	XXIX (10)	1103
manual control, cost .....	XXVI (07)	870
maximum power capacity .....	XXIX (10)	1094
mechanical difficulties .....	XXIII (04)	250

- Switch, oil, (*continued*)
- merits on cable circuits.....XXIII (04) 245
  - Niagara Falls plant .....XVIII (01) 494
  - operating mechanism, requirements.....XXIX (10) 1102
    - record, actual service.....XXIX (10) 1107
  - Pacific Gas & Electric Co.....XXIX (10) 714
  - protection with choke coils.....XXIX (10) 1095
  - pneumatically operated, Metropolitan Trac-  
tion Co. ....XVIII (01) 410
  - pumping .....XXIX (10) 1112, 1114
  - short-circuit currents, performance records..XXIII (04) 249
  - speed of break .....XVIII (01) 160
  - tanks, high-tension service.....XXVI (07) 1342
    - insulation from ground, advisability..XXIX (10) 728
  - tests on Standard Electric Co. lines.....XXIII (04) 221
  - top vs. bottom-connected, in high-tension  
service .....XXVI (07) 1341
  - trip-coil connections .....XXV (06) 576
  - type H, description.....XVIII (01) 409; XXIX (10) 1123
    - K, high-tension performance.....XVIII (01) 416
  - volume of oil, choice.....XXIX (10) 1113
    - relation to factor-of-safety..XXIX (10) 1092
  - vs. air-break .....XIX (02) 270
    - for induction motors.....XXIX (10) 168
  - power of short-circuits .....XXIX (10) 1117
  - rating, relation to generator regulation.....XXV (06) 560
  - sectionalizing, functions .....XXV (06) 572
  - selector, functions .....XXV (06) 569
  - tests at Kalamazoo .....XVIII (01) 415
  - transformer functions .....XXV (06) 571
- Switchboard, bench control, advantages.....XIX (02) 806
- disadvantages .....XIX (02) 771, 804
  - central station, typical layout.....XXIV (05) 34
  - high-tension .....XXVI (07) 1336
    - design .....XXVI (07) 1333
  - location, choice .....XIX (02) 804
  - Navy, arrangement .....XIX (02) 599
  - wiring .....XIX (02) 600
  - telephone (see Telephone).
- Switching, high-tension, practice .....XXIII (04) 594
- stations, outdoor .....XXVIII (09) 189
- Symbols for telegraph circuits.....XXIX (10) 1347, 1353
- Synchronizing, dangers .....XVIII (01) 430
- impedance and reactance coils.....XXV (06) 453
  - mechanical analogy .....XVIII (01) 784
  - power, definition .....XXVII (08) 235
  - synchronous machines, formula...XXVI (07) 1043
- Synchronous reversing key, description.....XXIX (10) 1518
- Synchroscope induction, mode of operation.....XVIII (01) 255
- Tanks for weighing condensed steam, construction.....XXIX (10) 1701
- Tantalum filaments (see Filaments).
- lamps (see Lamps).
  - melting point .....XXIX (10) 927
  - resistivity, temperature coefficient.....XXV (06) 822
  - tensile strength .....XXIX (10) 927
- Targets, lighting .....XXIX (10) 142

## 339

Taylor's Falls transmission line, description.....	xxvii	(08)	398
lightning performance.....	xxvii	(08)	770
Telautograph, Army type, description.....	xxiii	(04)	654
line e. m. f. ....	xxiii	(04)	652
resistance .....	xxiii	(04)	652
multiple connection .....	xxiii	(04)	652
principles of operation .....	xxiii	(04)	647
series connection .....	xxiii	(04)	652
transmission, distance limit.....	xxiii	(04)	656
Telegraph, automatic, Foote & Randall.....	xxix	(10)	1305
Leggo system .....	xxix	(10)	1310
circuit disturbances, defects in neutralizing			
transformers .....	xxvii	(08)	1684
methods of mapping.....	xxix	(10)	1331
symbols, Atchison & Topeka.....	xxix	(10)	1353
Baltimore & Ohio.....	xxix	(10)	1347
Canadian Pacific .....	xxix	(10)	1347
Northern Pacific .....	xxix	(10)	1347
duplex, beginning .....	xxix	(10)	1311
electrolytic rectifiers, use.....	xxix	(10)	1315
engineering history .....	xxix	(10)	1303
present practice .....	xxix	(10)	1303
field outfit, description.....	xix	(02)	710
first application under war conditions.....	xix	(02)	708
electric in U. S. ....	xxix	(10)	1303
frequency in different systems.....	xxviii	(09)	1172
generators, arrangement .....	xxix	(10)	1313
history .....	xxix	(10)	1303
inductance, Applegate neutralizing device.....	xxix	(10)	1326
Blakeney-Chetwood neutralizing			
device .....	xxix	(10)	1327
neutralizing transformer.....	xxix	(10)	1327
Wilson neutralizing device.....	xxix	(10)	1325
inductive disturbances, neutralizing devices.....	xxix	(10)	1325
instruments for testing circuits.....	xxix	(10)	1333
Johnson coil, definition.....	xxix	(10)	1322
line, concrete poles, use.....	xxix	(10)	1344
construction .....	xxix	(10)	1334
early methods .....	xxix	(10)	1305
economy of reliability.....	xxix	(10)	1348
crossing power lines, protection.....	xxix	(10)	913
disturbances from a. c. lines, prevention.....	xxviii	(09)	1241
single-phase railroad			
circuits .....	xxviii	(09)	1221
single-phase railroad,			
experience, N. Y.			
N. H. & H. R. R.....	xxviii	(09)	1225
effects of grounded transmission systems.....	xxix	(10)	710
electromagnetic disturbances, neutraliza-			
tion .....	xxviii	(09)	1175
electrostatic disturbances, neutralization.....	xxviii	(09)	1175
Martin mecograph, description.....	xxix	(10)	1319
phantoplex circuits, description .....	xxix	(10)	1321
poles (see Poles).			
printing, Buckingham-Barclay, transmission			
speed .....	xxix	(10)	1316
ideal requirements.....	xxix	(10)	1346, 1350, 1354

Telegraph, printing, (*continued*)

Rowland, circuit diagram.....	xxvi	(07)	532
current consumption.....	xxvi	(07)	519
description .....	xxvi	(07)	508
mode of operation.....	xxvi	(07)	526
Potts synchronizer.....	xxvi	(07)	521
speed .....	xxvi	(07)	513
transmission speed.....	xxix	(10)	1316
Wheatstone, transmission speed.....	xxix	(10)	1317
Wright, description .....	xxix	(10)	1318
rates in 1881 .....	xxix	(10)	1309
relay, 150-ohm, characteristics, test.....	xxviii	(09)	1173
Morse duplex, current consumption.....	xxvi	(07)	546
quadraplex, current consumption .....	xxvi	(07)	546
resistance, early types.....	xxix	(10)	1328
repeater, direct-point, description.....	xxix	(10)	1320
signal, used on warships.....	xix	(02)	614
system, Mexico Republic.....	xxix	(10)	1343
telephone composite circuits.....	xxix	(10)	1322
testing instruments .....	xxix	(10)	1333
wireless, aerial types used on board ships.....	xix	(02)	573
coherer, inventor .....	xix	(02)	573
government interference.....	xxvii	(08)	614
maximum distance .....	xix	(02)	574
range compared with wireless tele- phone .....	xxvii	(08)	613
stations, lightning disturbances.....	xxvii	(08)	785
transmitter, non-syntonic, connec- tion .....	xix	(02)	572
syntonic .....	xix	(02)	574
U. S. Navy.....	xix	(02)	569
writing, Cowper and Robertson, description.....	xxiii	(04)	645
Gray, description .....	xxiii	(04)	646
Telegraph-telephone circuits .....	xxix	(10)	1322
Telegraphy (see Telegraph).			
Telephone, automatic, adaptability to large systems.....	xxv	(06)	99
advantages .....	xxi	(03) 49; xxix	(10) 90
apparatus, durability .....	xxix	(10)	89
attendants required .....	xxix	(10)	76
branch office, definition.....	xxvii	(08)	532
Brooklyn Rapid Transit Co. plant.....	xxix	(10)	96
central office equipment.....	xxix	(10)	59
equipment cost com- pared with manual.....	xxvii	(08)	511
equipment, life.....	xxvii	(08)	520
maintenance, cost.....	xxvii	(08)	518
operation, cost.....	xxvii	(08)	518
repairs, cost.....	xxvii	(08)	518
compared with semi-automatic and manual .....	xxix	(10)	99
connector switch, construction.....	xxix	(10)	59
Connolly & McTighe system, de- scription .....	xxi	(03)	31
construction and operation.....	xxix	(10)	55
component parts.....	xxix	(10)	59

Telephone, automatic, ( <i>continued</i> )		
cost of central office equipment....xxvii	(08)	508
trouble labor .....	xxvii	(08) 527
depreciation .....	xxix	(10) 93
formula for number of trunking		
switches .....	xxvii	(08) 509
Havana, Cuba, system.....	xxix	(10) 79
line switch, construction.....	xxix	(10) 70
description .....	xxix	(10) 1361
metered service .....	xxix	(10) 1367
Michigan Agric. College plant.....	xxix	(10) 94
operation compared with manual....	xxi	(03) 32
description .....	xxix	(10) 56
plant, first cost.....	xxvii	(08) 505
maintenance .....	xxix	(10) 92
private branch operation.....	xxix	(10) 1369
San Francisco system.....	xxix	(10) 80
description.....	xxix	(10) 1357
secondary line switch, construction.....	xxix	(10) 77
selector switch, construction.....	xxix	(10) 63
space requirements compared with		
manual plant .....	xxvii	(08) 512
Strowger system, construction of		
apparatus ....	xxix	(10) 55
equipment .....	xxix	(10) 55
mode of opera-		
tion .....	xxix	(10) 55
substations, advantages.....	xxvii	(08) 547
definition .....	xxvii	(08) 532
suburban toll, back checking.....	xxix	(10) 1372
operation .....	xxix	(10) 1371
switchboard, cost of energy con-		
sumed.....	xxvii	(08) 522
lighting.....	xxvii	(08) 522
toll checking apparatus.....	xxix	(10) 1374
troubles .....	xxix	(10) 90
trunking circuits .....	xxix	(10) 1363
methods between large		
offices .....	xxvii	(08) 532
two-wire interconnected with three-		
wire system .....	xxix	(10) 1376
underground substations, construc-		
tion .....	xxvii	(08) 546
cables (see Cables).		
central office location.....	xxvi	(07) 572
plant, life .....	xxv	(06) 107
common battery advantages over magneto.....	xxi	(03) 84
cost of energy supply.....	xxi	(03) 87
effect on cable maintenance.....	xxi	(03) 68
plant, first cost.....	xxvii	(08) 505
circuits (see Circuits).		
distribution, interior block method.....	xxvi	(07) 580
disturbances from different kinds of a.c.		
circuits .....	xxviii	(09) 1190
engineer, functions .....	xxi	(03) 81
relation to telephone organization....	xxv	(06) 103
engineering, definition .....	xxv	(06) 81

Telephone, engineering, (*continued*)

early experiences .....	XXV (06)	106
scope .....	XXV (06)	82
exchanges, choice of number.....	XXVI (07)	576
first in Boston.....	XXI (03)	71
load curve, Boston.....	XXI (03)	78
Chicago .....	XXI (03)	77
New York .....	XXI (03)	78
typical .....	XXI (03)	76
location .....	XXVI (07)	572
relation between number and size		
of city .....	XXVI (07)	576
field outfit, description.....	XIX (02)	715
fuse for protection from high tension, tests.....	XXV (06)	358
high-tension lines .....	XXVIII (09)	1187
lines, clearance with transmission lines.....	XXIII (04)	589
construction for high-tension lines.....	XXIII (04)	585
crossing power lines, protection.....	XXIX (10)	913
disturbances from a. c. lines, preven-		
tion .....	XXVIII (09)	1241
from power lines.....	XXI (03)	245
from power lines, methods		
of minimizing.....	XXI (03)	249
from single-phase railroad,		
experience, N. Y. N. H.		
& H. R. R.....	XXVIII (09)	1225
from single-phase railroad,		
neutralizing devices, dis-		
advantages .....	XXVIII (09)	1234
inductive, development of		
equations .....	XXVI (07)	1155
effect of grounded transmission system.....	XXIX (10)	710
electromagnetic induction, formulas.....	XXVI (07)	1163
first hard copper .....	XXVI (07)	598
insulating transformers, objections to		
use .....	XXVIII (09)	1236
insulators for circuits paralleling high-		
tension lines .....	XXIX (10)	723
parallel high-tension lines, choice of		
insulators .....	XXIX (10)	723
high-tension lines, experience.....	XXVIII (09)	1232
protection.....	XXVIII (09)	1237
power lines, design.....	XXI (03)	285
power lines, experimental de-		
termination of transposition.....	XXIII (04)	684
transmission lines, disturb-		
ances .....	XXI (03)	245
transmission line, operation.....	XXIX (10)	710
protection from power lines.....	XXII (03)	764
transposition (see Transposition).		
magneto, cost of maintaining generator.....	XXI (03)	86
disadvantages .....	XXI (03)	84
manual, central office equipment, life.....	XXVII (08)	520
maintenance, cost.....	XXVII (08)	518
repairs, cost .....	XXVII (08)	518
compared with automatic and semi-		
automatic .....	XXIX (10)	99

Telephone, manual, (*continued*)

delays in New York system, record....XXI	(03)	57
disadvantages .....	XXI	(03) 52
maximum number of lines on one		
switchboard .....	XXVII	(08) 505
operation, cost.....XXVII	(08) 518; XXIX	(10) 91
switchboard, cost of energy consumed.XXVII	(08)	522
lighting .....	XXVII	(08) 522
time required for connection.....XXI	(03)	64
work, reach of operator.....XXI	(03)	53
natural period of human ear.....XXVIII	(09)	1187
operators, method of instructing in New York.XXI	(03)	66
working reach .....	XXI	(03) 53
plant, battery rating required.....XXV	(06)	96
calls per line per day in different sized		
systems .....	XXVII	(08) 506
compared with central station.....XXI	(03)	59
construction period for which it should		
be planned .....	XXV	(06) 83
cost analysis .....	XXVII	(08) 504
depreciation, automatic system...XXIX	(10) 89, 93,	98
efficiencies .....	XXI	(03) 79
extent of New York system.....XXVI	(07)	596
functions .....	XXI	(03) 59
general method of laying out.....XXVI	(07)	569
life, rubber covered wire.....XXVI	(07)	585
maintenance, automatic system.....XXIX	(10)	92
operation cost, automatic system.....XXIX	(10)	92
manual system .....	XXIX	(10) 91
population growth, method of study....XXVI	(07)	570
range of audible frequency.....XXVIII	(09)	1186
relay, Edison's loud-speaking phone.....XXVIII	(01)	54
service, delays in New York, record.....XXI	(03)	57
essential features .....	XXI	(03) 73
methods of charging.....XXV	(06)	92
quality tests, Chicago.....XXIX	(10)	102
New York .....	XXI	(03) 64
time required for manual connection...XXI	(03)	64
toll line, methods of charging.....XXV	(06)	94
switchboard, choice of type.....XXV	(06)	86
early, in New York City.....XXI	(03)	6
equipment, life .....	XXV	(06) 84
evolution .....	XXI	(03) 3
maximum line capacity.....XXVII	(08)	505
multiple, date of invention.....XXI	(03)	8
relay type, description.....XXI	(03)	4
standard relay, development.....XXI	(03)	13
simplified arrange-		
ment .....	XXI	(03) 90
Western Union pin, description...XXI	(03)	5
systems, classification .....	XXVIII	(09) 1179
telegraph, composite circuits.....XXIX	(10)	1322
traffic, calls per line per day in different sized		
plants .....	XXVII	(08) 506
effect of fixed charges on division of		
service in manual and automatic		
systems .....	XXVII	(08) 524

- Telephone, traffic, (*continued*)
- engineer, functions .....xxv (06) 109
  - percentage calls trunked out of Cort-  
landt street office, New York.....xxvii (08) 550
  - two-number business, definition.....xxv (06) 111
  - transmission standard, definition.....xxv (06) 107
  - troubles, cost of labor for clearing, with auto-  
matic and manual plants.....xxvii (08) 527
  - wire plant, extent New York system.....xxvi (07) 596
  - wireless, atmospheric absorption, tests.....xxvii (08) 608
  - brief history .....xxvii (08) 578
  - choice of spark frequency.....xxvii (08) 578
  - Ernest Ruhmer experiments.....xxi (03) 375
  - Fessenden system, mode of opera-  
tion .....xxvii (08) 603
  - possibilities .....xxvii (08) 606
  - flame transmitter .....xxi (03) 382
  - government interference .....xxvii (08) 614
  - radiophone experiments .....xxi (03) 375
  - range compared with wireless tele-  
graph .....xxvii (08) 613
  - relay for amplifying currents, de-  
scription .....xxvii (08) 593
  - theory .....xxvii (08) 575
  - transmitters, description .....xxvii (08) 590
  - transmitting circuits, typical.....xxvii (08) 596
- Telephone-telegraph, circuits .....xxix (10) 1322
- Telephonograph, Poulsen, description.....xviii (01) 47
- Tell-tale papers (see Lightning arresters).
- instructions for use.....xxiv (05) 951
- Telluride Power Co., early experience with outlet bushings.xxv (06) 865
- surge tests .....xxiv (05) 322
- Telpherage, applications .....xix (02) 452
- derivation of word.....xix (02) 435
  - early history .....xix (02) 437
  - overhead construction, types.....xix (02) 438
  - power requirements, different grades and  
speeds .....xix (02) 449
  - speeds .....xix (02) 448
  - weights conveyed .....xix (02) 442
- Telphers, brakes, types used.....xix (02) 445
- construction .....xix (02) 442
  - motor, requirements .....xix (02) 444
  - power requirements, different grades and speeds.xix (02) 449
  - speeds .....xix (02) 448
- Temperature coefficients, thermal, of various materials  
(see name of material).
- distribution in furnace electrodes with  
uniform thermal resistivity.....xxix (10) 476
  - distribution in furnace electrodes with  
variable thermal and electrical resistivity.xxix (10) 479
  - drop, tests .....xviii (01) 510
  - electric machines, measurement.....xviii (01) 482
  - extreme variation in cold climates in U. S..xxiii (04) 515
  - generator room on warships.....xix (02) 735
  - maximum in power stations.....xix (02) 699



- Temperature (*continued*)
- measurement by electrical means.....xxv (06) 473
    - pyrometers (see Pyrometers).
    - railway motor in operation...xxii (03) 291
    - resistance compared with
      - thermometer .....xviii (01) 535
      - thermometer...xviii (01) 535; xxii (03) 685
  - Moore tube .....xxvi (07) 637
  - Nernst glower .....xviii (01) 578
  - range, South Appalachian system.....xxiv (05) 802
  - records, electrical machinery, value.....xxix (10) 350
  - rise in conductors cooled by thermal con-
    - duction .....xxvi (07) 973
    - induction motors, calculations.....xxviii (09) 528
    - starting, calculation...xxviii (09) 554
    - measurement in insulation.....xix (02) 1049
  - Temperature-entropy diagram, steam engine-exhaust tur-
    - bine unit .....xxvi (07) 1756
  - Temperature-loss diagram for induction motors.....xxviii (09) 539
  - Temperature resistance formula.....xxvi (07) 970
  - Tensile strength, various materials (see name of material).
  - Tension equalizer, catenary construction (also see Rail-
    - ways) .....xxix (10) 990, 992
  - Terminal bushings (see Bushings).
  - Terminals, bushings, condenser type.....xxviii (09) 209
    - high-tension, effective resistance.....xxix (10) 1224
    - size .....xxix (10) 1223
  - Testing various apparatus (see name of apparatus).
  - Textile mills, cost of heating, actual.....xxix (10) 388
    - effect of speed variation on production...xxix (10) 419, 424
    - electric drive, analytical discussion...xxix (10) 385, 390
      - effect on speed variation,
        - actual .....xxix (10) 392
        - first cost .....xxix (10) 385
        - flexibility, example .....xxix (10) 391
      - load-factors .....xxix (10) 159, 163
      - location, choice .....xxix (10) 115
      - mechanical drive, cost.....xxix (10) 386
      - power used by all cotton mills in U. S.....xxix (10) 426
      - selection of number of machines for group
        - drive .....xxix (10) 167
        - slashing cost, actual .....xxix (10) 388
  - Thermal efficiency (see Efficiency).
  - Thermit, energy of reaction.....xxi (03) 386
    - temperature of reaction.....xxi (03) 386
  - Thermo-couples, e. m. f.-temperature relation.....xxv (06) 503
  - Thermodynamic heating .....xxvii (08) 1607, 1609
  - Thermo-e. m. f., electronic theory.....xxvi (07) 957
  - Third rail, construction, typical.....xxvi (07) 726
    - leakage and insulation tests.....xxvii (08) 1216
      - effect of polarity.....xxvii (08) 1220
    - location, New York Central.....xxvi (07) 729
      - standard .....xxvi (07) 135
    - London Underground roads.....xxvii (08) 1215
    - operation under snow and ice conditions.....xxvi (07) 734
    - resistance tests, with chemical composition
      - given .....xxvii (08) 1228

- Thomson automatic e. m. f. regulator.....xxvii (08) 265  
     continuous wave meter, description.....xxiv (05) 187  
     repulsion motor, theory.....xxiii (04) 16
- Thomson-Houston arc machine (see Generators, arc).
- Thury direct-current transmission system, characteristics.xxvi (07) 1582
- Tie wires, galvanized, corrosion.....xxi (03) 290
- Tirrell regulator (see Regulator).
- Tools, cutting rates .....xx (02) 124  
     machine (see Machine tools).
- Tower lines (see Transmission lines).  
     cost relation to length of span.....xxvi (07) 1233
- Towers, base relation between width and total cost.....xxvi (07) 1232  
     bending moment, formula .....xxvi (07) 1224  
     cost .....xxvi (07) 191  
         relation to width of base.....xxvi (07) 1232  
     equipotential lines about .....xxvi (07) 880  
     erection methods .....xxvi (07) 1289  
     footings, concrete, electric resistance.....xxvi (07) 1216  
         design .....xxvii (08) 937, 944  
     foundations, cost .....xxvi (07) 1236  
         design .....xxvii (08) 937  
     mechanical requirements .....xxvi (07) 1221  
     metal footings, holding-down power, tests.....xxvi (07) 1316  
     steel, advantages .....xxiii (04) 512  
         cost .....xxiii (04) 531  
         effect on lightning disturbances.....xxiii (04) 524, 537  
         wind pressure .....xxiii (04) 515  
     strains, classification .....xxvii (08) 942  
     strength, formulas .....xxvi (07) 1225  
     testing, methods .....xxvii (08) 940  
     weights expressed in terms of stresses.....xxvi (07) 1221  
     wind pressure, calculation .....xxvii (08) 932
- Track bonds (see Bonds).
- Tracks, bonded, resistance .....xxvii (08) 1143  
     disturbance, effect of dead weight.....xxix (10) 1440, 1449  
         high center of gravity.....xxix (10) 1426,  
             1441, 1445  
     location of locomotive  
         springs .....xxix (10) 1450  
     gauge, standard, origin .....xix (02) 1016  
     impedance, calculation .....xxvii (08) 1146  
     reactance .....xxvii (08) 1144  
         field tests .....xxvii (08) 1171  
     resistance, field tests .....xxvii (08) 1171
- Tractors (also see Telfers).  
     electric, canal haulage tests, Lehigh canal.....xxvii (08) 278  
     efficiency, hauling canal boats.....xxvii (08) 287  
     friction losses, hauling canal boats....xxvii (08) 289
- Train lighting (see Lighting).  
     movement, acceleration calculations.....xix (02) 137  
         distance equations.....xix (02) 146  
         energy equations.....xix (02) 146  
         formulas, derivation.....xix (02) 976  
         motor curves .....xix (02) 140  
         power equations.....xix (02) 146  
         through, definition.....xix (02) 133

Train movement, (*continued*)

analysis .....	XIX (02)	907
braking curves, plotting.....	XIX (02)	934
calculation, Carter vs. Mailloux method.....	XXII (03)	165
data, tabulation .....	XXII (03)	161
general equation .....	XXII (03)	171
Hutchinson's method, appli-		
cation .....	XIX (02)	204
inertia of rotating parts.....	XIX (02)	167
speed-time curves, early use.....	XIX (02)	902
coasting curves, plotting.....	XIX (02)	934
distance- time curves, plotting.....	XIX (02)	937
economy of high acceleration.....	XIX (02) 188, 192,	194
general equations .....	XXII (03)	137
inertia of rotating parts.....	XIX (02)	166
initial acceleration, effect of grades.....	XIX (02)	182
kinematics .....	XXII (03)	135
Mailloux method of plotting speed-time		
curves .....	XIX (02)	923
problem, general equation.....	XIX (02) 129,	131
service run, calculation by Mailloux		
method, example.....	XIX (02)	945
curves, plotting.....	XIX (02)	941
speed-time curves, Mailloux coeffi-		
cients .....	XIX (02)	926, 930
resistance .....	XXIV (05)	528
curves, Davis tests .....	XIX (02)	810
discussion .....	XXIII (04)	730
due to grades.....	XIX (02)	913
track curvature .....	XIX (02)	913
formula, Baldwin Locomotive Works.....	XXIII (04)	695
comparison of various.....	XXIII (04)	732
Davis, compared with tests.....	XXIII (04)	697
Goss-Mailloux .....	XXIII (04)	731
Smith, compared with tests.....	XXIII (04)	697
W. J. Davis.....	XXIII (04)	696
W. N. Smith.....	XXIII (04)	696
tables, various authorities.....	XXVII (08)	1150
Transformer, advantages between transmission and dis-		
tribution circuits .....	XVIII (01)	841
air-blast, fire risk, reduction.....	XXIII (04)	194
power for blowers.....	XXIII (04)	236
cases, grounding, method.....	XXIII (04)	233
choke coil, inside case.....	XXVI (07)	1172
coil construction with extra insulation on		
end turns .....	XXVI (07)	1174
constant-current instability .....	XXVIII (09)	17
regulation characteristic.....	XXVIII (09)	19
cooling, forced-oil, advantages.....	XXVI (07)	846
amount water required.....	XXVI (07)	836
DeCew Falls installa-		
tion .....	XXVI (07)	841
description .....	XXVI (07)	835
disadvantages .....	XXVI (07)	846
first installation.....	XXVI (07)	849
increase in rating.....	XXVI (07)	841
piping system.....	XXVI (07)	836

Transformer, cooling, forced-oil, (*continued*)

saving .....	XXVI (07)	836
forced-water, advantages.....	XXVI (07)	845
practice .....	XXIII (04)	591
self, limitations .....	XXVI (07)	840
water, limitations .....	XXVI (07)	840
connection to high-tension lines.....	XXIII (04)	590
copper loss test .....	XXVI (07)	1181
core losses, effect of wave form.....	XXIX (10)	892
test.....	XXVI (07) 1181; XXVIII (09)	417
effect of wave distortion....	XXV (06)	708;
XXVI (07) 1182; XXVIII (09)		418
core-type, insulating value.....	XXIX (10)	1603
cost-efficiency characteristic .....	XXV (06)	156
delta-connected, exciting current wave....	XXV (06)	700
direct-current in windings, effect.....	XXVIII (09)	729
eddy-current loss, variation with flux		
density .....	XXVIII (09)	455, 458
variation with fre-		
quency .....	XXVIII (09)	462
efficiency-cost characteristic .....	XXV (06)	156
e. m. f. regulation for high-tension insula-		
tor tests .....	XXI (03)	312
wave, effect of series resistance.....	XXII (03)	368
equations, method of teaching.....	XXI (03)	595
equivalent electric circuit.....	XXVII (08)	1409
exciting current, effect of third harmonic....	XXV (06)	673
test .....	XXVI (07)	1181
effect of wave dis-		
tortion .....	XXVI (07)	1182
wave distortion .....	XXIX (10)	809
due to		
iron....	XXV (06)	692
faults, method of detection.....	XXII (03)	752
frequency of maximum economy.....	XXVI (07)	1400
graded insulation .....	XXIX (10)	1602
ground shield, definition .....	XXIII (04)	553
objections to use.....	XXIII (04)	554
harmonics in currents and e. m. f's., ex-		
perimental investigation.....	XXIX (10)	809
observed in actual service.....	XXIX (10)	873
high-tension, 500,000 volts .....	XXVIII (09)	221
bushings, corona (see Corona).		
outdoor .....	XXVIII (09)	180
experience .....	XXVIII (09)	228
several voltages, construc-		
tion .....	XXIII (04)	229
tests .....	XXVI (07)	1184
e. m. f., choice .....	XXI (03)	324
waterproof .....	XXVIII (09)	255
house (see Substation).		
hysteresis loop from exciting current wave....	XXV (06)	675
plotted from exciting cur-		
rent wave .....	XXIX (10)	844
loss, variation with flux den-		
sity .....	XXVIII (09)	455, 458

Transformer, (*continued*)

- impedance triangle, measurement.....XXIX (10) 1285
- instrument (also see Transformers, series and shunt).
  - advantages in high-tension measurements .....XXIV (05) 445
  - Bureau Standards, methods of testing .....XXVIII (09) 1044
  - compartment, typical construction .....XXIV (05) 34
  - limitations for high-tension measurements .....XXIV (05) 422
  - performance .....XXVIII (09) 1005
    - on unbalanced circuits .....XXVIII (09) 1254, 1272
  - regulation, direct measurement .....XXIX (10) 1298
  - testing, production of load of given power-factor..XXIX (10) 1533
    - with electrodynamic-meters .....XXIX (10) 1544
- insulating, for telephone lines, objections to use .....XXVIII (09) 1236
- insulation, condenser type .....XXVIII (09) 220
  - effect of grounded neutral.....XXII (03) 386
    - triple frequency e.m.f..XXIX (10) 860
  - end turns, construction.....XXVI (07) 1174
  - graded .....XXIX (10) 1602
  - micanite, advantages .....XXIX (10) 712
  - relative value core-type and shell type .....XXIX (10) 1603
- interconnected harmonic, explanation.....XXIX (10) 900
  - observation of harmonics..XXIX (10) 853
- iron losses, effect of wave form.....XXIII (04) 411
- magnetic bias, definition.....XXVIII (09) 728
- maximum size feasible to build.....XXIII (04) 802
- measurement of large direct-currents.....XXVIII (01) 171
- neutralizing, defects .....XXVII (08) 1684
- oil, fires, experience.....XXIII (04) 193, 195
  - fireproofing, method .....XXIII (04) 187
  - fire risk .....XXIII (04) 176
    - Snoqualmie Falls .....XXIII (04) 180
  - flooding with water, method.....XXIII (04) 192
  - method of withdrawing oil, emergency.XXIII (04) 183
- oils (see Oil).
- open-delta performance on unbalanced e. m. f. ....XXVIII (09) 573
- operation with leak in water coil.....XXIX (10) 725
- outdoor, non-freezing oil.....XXVIII (09) 244
- overload capacity .....XXVIII (01) 648
- Pearson static by-pass.....XXIII (04) 568
- penetration distance of disturbance into winding .....XXVI (07) 1195
- performance, calculation .....XXVII (08) 1409
  - unbalanced circuits.....XXVIII (09) 1256
- polarity test .....XXVI (07) 1181
- pole, faults detection, method.....XXII (03) 752

Transformer, (*continued*)

polyphase connections, potential strains.....XXII	(03)	392
observation of harmonics.....XXIX	(10)	865
potential strains, double transformation, different connections..XXII	(03)	402
due to lightning dis- turbances ....XIX	(02)	257
short circuits...XIX	(02)	257
switching .....XIX	(02)	257
polyphase grounded.....XXII	(03)	392
ungrounded..XXII	(03)	392
single-phase grounded..XXII	(03)	390
single transformation, different connections..XXII	(03)	401
single-phase ungrounded..XXII	(03)	390
ratio function of phase displacement.....XVIII	(01)	355
test .....	XXVI	1180
regulation, calculation, degree of accuracy..XXIX	(10)	1291
effect of magnetizing current..XXVIII	(09)	473
phase and e. m. f. un- balance .....	XXVIII	1253
on wave form.....XVIII	(01)	360
formula .....	XXIX	1293
test .....	XXVI	1184
variable phase displacement...XVIII	(01)	356
reinforcement of insulation of end turns...XXVI	(07)	1175
resistance test .....	XXVI	1181
selection .....	XXIII	236
self-cooled, power limit.....XXVIII	(09)	189, 231
series, errors in power measurements.....XXIV	(05)	168
hysteresis losses .....	XXV	722
inductance measurements .....	XXV	718
magnetization curve .....	XXV	722
performance .....	XXVIII	1268
calculation .....	XXV	720
characteristics .....	XXV	716
tests .....	XXV	727
theory .....	XXVIII	1015
unbalanced circuits..XXVIII	(09)	1254, 1272
phase angle, calculation.....XXVIII	(09)	1027
errors .....	XXVIII	1010
measurement .....	XXV	730;
XXVIII (09) 1022, 1040, 1044;		
XXIX (10) 1522		
ratio calculation .....	XXVIII	1027
curves .....	XXV	724, 734
measurement...XXVIII	(09)	1021, 1040, 1044;
XXIX (10) 1522		
with mutual in- ductance .....	XXIX	1529
resistance effect on wave form.....XXV	(06)	713
testing table, connections.....XXIX	(10)	1528
uses .....	XXV	715
wave distortion, measurement.....XXIX	(10)	1523
shell-type, insulating value.....XXIX	(10)	1603

Transformer, (*continued*)

shunt, errors in power measurements.....	XXIV	(05)	167
phase angle, measurement.....	XXVIII	(09)	1034
ratio measurement .....	XXVIII	(09)	1033
testing methods .....	XXIX	(10)	1531
single-phase grounded, potential strains.....	XXII	(03)	391
ungrounded, potential strains.....	XXII	(03)	390
star-connected, exciting-current wave.....	XXV	(06)	701
static protector .....	XXIII	(04)	568
steels, aging tests .....	XXVIII	(09)	406
losses, effect of direction of rolling.....	XXVIII	(09)	462
magnetic properties .....	XXVIII	(09)	464
relation between losses and flux den-			
sities in various.....	XXVIII	(09)	461
test specimen, requirements.....	XXVIII	(09)	440
testing .....	XXVIII	(09)	439
taps in middle of winding.....	XXVI	(07)	1176
terminals, bushings, condenser type.....	XXVIII	(09)	209
materials .....	XXIII	(04)	227
design .....	XXIII	(04)	225
high-tension insulation.....	XXIII	(04)	226
internal, design .....	XXIII	(04)	234
testing, general instructions.....	XXVI	(07)	1179
three-phase, advantages for pole installa-			
tion .....	XXVI	(07)	829
core-type merits compared			
with shell type.....	XXVI	(07)	828
cost compared with single-			
phase bank.....	XXVI	(07)	814, 833
delta-star grounded, potential			
strains .....	XXII	(03)	397
experience, Chicago Edison.....	XXVI	(07)	822
floor space, compared with			
single-phase bank.....	XXVI	(07)	814
merits compared with bank			
of single-phase.....	XXVI	(07)	813, 817
regulation compared with			
single-phase bank .....	XXVI	(07)	830
shell-type merits compared			
with core-type .....	XXVI	(07)	828
star, grounded, experience.....	XXII	(03)	408
potential			
strains .....	XXII	(03)	394
ungrounded, potential			
strains .....	XXII	(03)	394
star-delta, grounded, poten-			
tial strains .....	XXII	(03)	397
T-connection, grounded, po-			
tential strains .....	XXII	(03)	394
T-connection, ungrounded, po-			
tential strains .....	XXII	(03)	394
vs. single-phase bank.....	XXVI	(07)	817
T-connected, potential rises.....	XXII	(03)	388
two-phase, four-wire, grounded, potential			
strains .....	XXII	(03)	392
four-wire, ungrounded, poten-			
tial strains .....	XXII	(03)	392

Transformer, two-phase, (*continued*)

three-wire, grounded, strains....xxii	(03)	393
ungrounded, strains....xxii	(03)	393
use in d. c. Brush arc circuits.....xxviii	(09)	33
water-cooled, protection from frost.....xxviii	(09)	239
windings, distribution of sudden stress.....xxv	(06)	906
distribution of sudden stress with		
inductance, tests .....	xxv	(06) 886
Y-connected, potential rises.....xxii	(03)	388
Transmission, cost calculation .....	xxiii	(04) 769
d. c., economy compared with three-phase		
and single-phase .....	xxvi	(07) 1574
Thury system, characteristics.....xxvi	(07)	1582
factors that limit distance.....xxiii	(04)	760
frequency, choice .....	xxiii	(04) 783
limit with given size wire.....xxiii	(04)	534
maximum distance, factors that determine.xxiii	(04)	760
relation to conductor..xxiii	(04)	765
drop.....xxiii	(04)	764
e. m. f.....xxiii	(04)	763
net profit..xxiii	(04)	766
power de-		
livered...xxiii	(04)	768
lines, aluminium, advantages.....xxiii	(04)	535
artificial, circuit diagram.....xxviii	(01)	342
bound charges, theory.....xxvii	(08)	421
broken insulators, location.....xxvi	(07)	1320, 1330
calculation, errors in approximate		
methods .....	xxvii	(08) 1426
capacity, approximate representation.xxvii	(08)	1406
calculation .....	xxiii	(04) 666
effect of relative position		
of conductors .....	xxiii	(04) 671
formula....xxiii	(04) 669; xxvi	(07) 163
derivation .....	xxvi	(07) 556
susceptance factors, table..xxvii	(08)	1422
charging current, effect upon gene-		
rator regulation..xxii	(03)	375
wave form.....xxviii	(01)	365
clearance, standard to ground.....xxiii	(04)	518
to telephone lines.....xxiii	(04)	589
construction, first Buffalo-Niagara		
Falls line.....xxviii	(01)	512
factor-of-safety .....	xxvii	(08) 939
report of High Ten-		
sion Committee.....xxiii	(04)	571
second Niagara Falls-		
Buffalo line.....xxviii	(01)	518
solid vs. stranded con-		
ductors .....	xxviii	(01) 421
with link-type insula-		
tors .....	xxvi	(07) 1263
corona phenomena (see Corona).		
cost relation to span between towers.xxvi	(07)	1233
critical e. m. f., calculation.....xxvi	(07)	169



Transmission, lines, (*continued*)

- crossarms (also see Crossarms).
  - bracing methods.....XXIII (04) 575
  - construction, high-tension
    - systems .....XXIII (04) 583
- crossings, classification, Southern
  - Pacific R. R.....XXIX (10) 910
  - railroad right-of-way.....XXIX (10) 905
  - Southern Pacific R. R.,
    - specifications .....XXIX (10) 906
  - specifications.....XXIX (10) 906, 916, 919, 921
- telephone and telegraph
  - circuits .....XXIX (10) 913
  - value of wire net.....XXIX (10) 911
- cross-section factors, table.....XXVII (08) 1420
- depreciation .....XXVIII (09) 1398
- discharge by leakage, time required..XXIV (05) 346
- disturbances, charging under differ-
  - ent conditions, tests.XXIV (05) 326
  - clearing short-circuit,
    - method .....XXIII (04) 204
  - effect of grounding
    - charged line.....XXIV (05) 340
  - electric charges (see Charges).
  - ground on ungrounded
    - three-phase line.....XXV (06) 405
  - lightning (see Lightning).
  - possible sources.....XXIV (05) 322
  - pressure rises between
    - lines .....XXV (06) 421
  - protection against
    - surges .....XXIV (05) 355
  - surges (see Surges).
  - standing waves (see Waves).
  - traveling waves (see Waves).
- drop compensator .....XXVII (08) 272
- economical span, determination..XXVI (07) 1233, 1249
- efficiency .....XXII (03) 250
  - effect of reactive load.....XVIII (01) 340
- electric charge, causes.....XXVI (07) 402
  - field distribution .....XXIII (04) 660
- e. m. f. and current distribution along
  - line, mechanical model.....XXI (03) 261
  - any point, formula.....XIX (02) 759
  - equalization between lines.....XXV (06) 421
  - maximum practicable .....XXIII (04) 228
  - relation to lightning disturb-
    - ances .....XXVI (07) 1051, 1206
  - rise due to interruption of
    - given current, formula.XXVI (07) 178
    - due to opening short-
      - circuit, calculation.....XVIII (01) 398
    - from spark-gap discharge.XVIII (01) 384
- electrostatic stress, effects.....XXVI (07) 406

Transmission, lines, (*continued*)

- energy leading and lagging, definition .....XXVIII (09) 616
- loss due to inductance of
  - grounded wire .....XXII (03) 337
  - stored, calculation .....XXVI (07) 167
- entries (see Entries).
- equation, Blondel .....XXVIII (09) 703
- hyperbolic .....XXVIII (09) 699
- opening short-circuit.....XVIII (01) 398
- Steinmetz .....XXVIII (09) 713
- Thomas .....XXVIII (09) 687
- faults, method of location.....XXVI (07) 1320, 1330
- frequency, effect on investment.....XXII (03) 380
- ground wire support, construction...XXVII (08) 418
- grounded, effect on telephone and
  - telegraph circuits.....XXIX (10) 710
  - neutral (see Grounded neutral).
  - wire (see Ground wire).
- high-tension, advantages of star-
  - connected generators.XXVI (07) 1635
  - critical wave length,
    - calculation .....XXVII (08) 1255
  - effect on sleet.....XVIII (01) 536
  - entries (also see Entries) .....XXIII (04) 578
  - construction .....XXII (03) 315
  - protection from
    - weather...XXII (03) 319, 327
    - requirements ...XXII (03) 314
  - first in world.....XXIX (10) 706
  - parallel operation, automatic sectionalization .....XXIX (10) 617
  - pole-top construction...XXIII (04) 601; XXVI (07) 434
  - power loss, measurement .....XXVII (08) 850, 858
  - short-pole and short-span system.....XXVII (08) 1560
  - suspended insulator,
    - construction...XXVI (07) 1259, 1263
  - telephones .....XXVIII (09) 1187
  - paralleling,
    - experience.XXVIII (09) 1232
  - transposition .....XXIII (04) 683
- inductance, effect of relative position
  - of conductors .....XXIII (04) 671
  - e. m. f., maximum.....XXII (03) 378
  - limit...XXII (03) 374
  - formula...XXIII (04) 663; XXVI (07) 163
  - derivation .....XXVI (07) 556
  - theory .....XXIII (04) 661
- insulation problem .....XVIII (01) 367
- insulators (see Insulators).
- pins (see Pins).

Transmission, lines, ( <i>continued</i> )		
interruptions, causes .....	XXIII (04)	511
investment, effect of frequency.....	XXII (03)	380
percentage of total.....	XXIII (04)	609
leakage conductance equations, gen- eral .....	XXVIII (09)	687
lightning (see Lightning).		
disturbances, theory.....	XXII (03)	331
location of lightning arresters.....	XIX (02)	253
to avoid lightning.....	XXV (06)	428
long-distance, analysis .....	XXVIII (09)	623
calculations .....	XXVIII (09)	641
numerical.....	XXVIII (09)	665
capacity adjustment.....	XXVIII (09)	618
effect .....	XXVIII (09)	616
control, location.....	XXVIII (09)	633
divided conductors.....	XXVIII (09)	636
drop method of con- trol .....	XXVIII (09)	622
economy, require- ments .....	XXVIII (09)	638
equations, general.....	XXVIII (09)	641
Blondel .....	XXVIII (09)	703
hyperbolic .....	XXVIII (09)	699
Steinmetz .....	XXVIII (09)	713
Thomas .....	XXVIII (09)	687
equations, split ca- pacity.....	XXVIII (09)	672
wave for- mula.....	XXVIII (09)	665
inductance adjust- ment .....	XXVIII (09)	618
inductance effect.....	XXVIII (09)	616
induction generator, advantages .....	XXVIII (09)	631
instability .....	XXVIII (09)	634
leading current supply.....	XXVIII (09)	625
performance under various conditions.....	XXVIII (09)	623
standing wave, equa- tions .....	XXVII (08)	1256
wave formula .....	XXVIII (09)	665
long-spans, experiments with alumi- num wire .....	XXIII (04)	527
method of construction.....	XXIII (04)	574
loss over insulators.....	XXIV (05)	343
magnetic field, distribution.....	XXIII (04)	660
maximum possible discharge of arresters.....	XXVI (07)	1127
frequency .....	XXVI (07)	1124
multiple conductors, inductance for- mulas .....	XXVIII (09)	678
natural period, calculation.....	XXVI (07)	165
calculation with dis- tributed capacity and inductance.....	XXII (03)	377
oil switches vs. air break.....	XIX (02)	270

Transmission, lines, (*continued*)

operation, practice .....	XXIII (04)	594
oscillating, distribution of potential and current .....	XXVI (07)	416
output limits of long-distance.....	XXVIII (09)	615
parallel, automatic sectionalization.....	XXIX (10)	720, 722
operation .....	XXIII (04)	547
performance, calculation .....	XXVII (08)	1401
constant receiver e.m.f., variable synchronous motor excitation.....	XVIII (01)	353
normal excited synchro- nous motor.....	XVIII (01)	350
over-excited synchro- nous motor.....	XVIII (01)	352
under-excited synchro- nous motor.....	XVIII (01)	347
pole construction, high-tension sys- tems .....	XXIII (04)	583
power capacity, maximum at differ- ent e. m. f.'s. and frequencies.....	XXII (03)	374
power-factor regulation with syn- chronous motors .....	XXIII (04)	486
protection, experience with Taylor's Falls system.....	XXVII (08)	397
from static disturbances.....	XIX (02)	243
general rules .....	XXII (03)	428
location of static inter- rupter .....	XIX (02)	247
overhead grounded wire, effectiveness .....	XXIX (10)	598
static interrupter.....	XIX (02)	246
protective apparatus, inspection.....	XXVI (07)	1053
reactance factors, table.....	XXVII (08)	1420
regulation (see Regulation). long distance .....	XXVIII (09)	615
relative economy, steel towers and wooden poles .....	XXVII (08)	832
resistance e. m. f., maximum.....	XXII (03)	378
limit.....	XXII (03)	374
factors, table .....	XXVII (08)	1420
resonance circuit, equation.....	XXII (03)	410
e. m. f. rise, formula.....	XVIII (01)	348
relation to charging current.....	XVIII (01)	346
tests .....	XXIV (05)	348
safety, objections to use of rubber gloves .....	XXII (03)	760
sag-span equation .....	XXIII (04)	516
sectionalizing .....	XXII (03)	442
short-circuit equations .....	XVIII (01)	398
short poles and short-spans.....	XXVII (08)	1560
single-phase performance, calculation.....	XXVII (08)	1401
static disturbances.....	XIX (02)	220
single-pin transposition .....	XXIII (04)	686

Transmission, lines, (*continued*)

span determination.....xxvi (07)	1233, 1249, 1251
over Winnipeg river, data on	
construction .....	xxvii (08) 457
standard branch lines, Lockport-	
Syracuse line... ..	xxvi (07) 1288
main line, Lockport-	
Syracuse line.....	xxvi (07) 1287
static discharges, effects.....	xxvii (08) 423
laws .....	xix (02) 215
disturbance due to bad syn-	
chronizing .....	xix (02) 239
due to charging	
branch .....	xix (02) 231
due to charging	
long line.....	xix (02) 228
due to charging	
short line.....	xix (02) 227
due to opening	
circuit .....	xix (02) 235
due to resonance.....	xix (02) 239
short-circuit.....	xix (02) 236
effect .....	xix (02) 221
from throwing on	
transformers .....	xix (02) 222
protection .....	xix (02) 243
tests .....	xix (02) 269
steel towers vs. wooden poles.....	xxvii (08) 832
switching practice .....	xxiii (04) 594
telephone circuits, operation.....	xxix (10) 710
three-phase four-wire, grounded, ex-	
perience .....	xxii (03) 412
performance, calculations.....	xxvii (08) 1403
power loss table.....	xxvii (08) 1423
topography, effect on lightning trouble.....	xxvii (08) 450
towers (see Towers).	
transposition, empirical rules.....	xxiii (04) 674
reasons .....	xxiii (04) 574
traveling wave, causes.....	xxvi (07) 411
tying conductor to pin insulator.....	xxvi (07) 1288, 1361
wave forms, oscillograms.....	xxiii (04) 403
waves, mechanical model.....	xix (02) 261
wind pressure .....	xxiii (04) 515
calculations .....	xxvii (08) 935
wires, electrical properties.....	xix (02) 218
wooden construction, cost in Cali-	
fornia, actual .....	xxix (10) 363
construction, cost compared	
with iron poles.....	xxiii (04) 155
pole construction, Taylor's	
Falls .....	xxvii (08) 398
pole-top construction, spans	
500 to 900 ft.....	xxvi (07) 1556
pole-top construction, spans	
900 to 3,000 ft.....	xxvi (07) 1558
vs. steel towers.....	xxvii (08) 832

- Transmission, lines, (*continued*)  
 plants (also see Power plants).  
   effect of small transformers on cost  
     of plant .....xxvii (08) 834  
   efficiency, three-phase compared with  
     direct-current .....xviii (01) 648  
   e. m. f. choice .....xxvii (08) 826, 842  
     effect on cost factors.....xxvii (08) 826  
   exhibit at World's Fair 1893, de-  
     scription .....xviii (01) 455  
   first three-phase in U. S.....xxii (03) 646  
   frequency, choice .....xxii (03) 378  
   ground as return .....xxvi (07) 1588  
   grounded neutral (see Grounded neutral).  
   high-tension, classification .....xxiii (04) 572  
     first in world.....xxix (10) 706  
   interruptions, record Buffalo-Niagara  
     line .....xxviii (09) 1422  
     record Pacific Gas &  
       Electric Co.....xxviii (09) 1420  
     record Shawinigan  
       plant .....xxviii (09) 1409  
   line investment .....xxiii (04) 609  
   load dispatching system.....xxviii (09) 1468  
     description.....xxix (10) 708  
   losses, distribution .....xxvi (07) 678  
   Niagara, Lockport & Ontario Power  
     Co., description .....xxvi (07) 1273  
   Pacific Gas & Electric Co.....xxix (10) 706  
   relative economy, direct-current,  
     single-phase and three-phase..xxvi (07) 1574, 1580  
   service continuity, general rules.....xxii (03) 428  
   short-circuit, method of clearing.....xxiii (04) 204  
   telephone lines, construction.....xxiii (04) 585  
   transformers (see Transformers).  
   troubles, classification .....xviii (01) 537  
   two-phase, from single-phase gene-  
     rators .....xix (02) 856  
   single-phase, economy compared with three-  
     phase and direct-current.....xxvi (07) 1574, 1580  
   three-phase, economy compared with single-  
     phase and direct-current.....xxvi (07) 1574, 1580  
   underground, cables (see Cables).  
 Transportation, conductor wire by mules.....xviii (01) 195  
   machinery by man .....xviii (01) 202  
     mules .....xviii (01) 197  
     wire rope .....xviii (01) 199  
   mountain, classification .....xviii (01) 191  
     mules .....xviii (01) 195  
     wire rope .....xviii (01) 199  
 Transposition, high-tension lines.....xxiii (04) 683  
   line conductors, empirical rules.....xxiii (04) 674  
   phantom .....xxiii (04) 679  
   single-pin .....xxiii (04) 686  
   telephone lines paralleling power lines.....xxiii (04) 679  
     paralleling power lines,  
       experimental determi-

Transposition, telephone lines ( <i>continued</i> )		
nation .....	xxiii (04)	684
transmission lines, reasons.....	xxiii (04)	574
Trolley, 3,000-volt, experience .....	xxiv (05)	143
construction, Berlin-Zossen tests .....	xix (02)	546
Lansing, St. John & St. Louis		
Electric Ry. ....	xxiv (05)	110
lining-up wire on curves.....	xxix (10)	1030
Spindlerfeld railway .....	xxiv (05)	103
three-phase .....	xviii (01)	110
Valtellina railway .....	xxiv (05)	100
single-phase, wire wear .....	xxvii (08)	1697
tension in contact wire.....	xxix (10)	1013
voltage choice for single-phase railways.....	xxiv (05)	116
wire, standard location .....	xxvi (07)	135
Trucks, compensation for re-distribution of force due		
to braking .....	xx (02)	257
force distribution during braking.....	xx (02)	254
Tuma phase meter, mode of operation .....	xviii (01)	291
Tungsten, drawn, resistivity, electric.....	xxix (10)	965
temperature coeffi-		
cient .....	xxix (10)	965
specific gravity .....	xxix (10)	965
tensile strength .....	xxix (10)	965
filaments (see Filaments).		
lamps (see Lamps).		
mechanical working .....	xxix (10)	963
melting point.....	xxv (06) 816, 856; xxix (10)	930
resistivity, electric, temperature coefficient.....	xxv (06)	822
specific gravity .....	xxix (10)	930
Tuning fork electrically driven, description.....	xviii (01)	719
Tunnel gases, electric protection.....	xxix (10)	371
water, cost .....	xxv (06)	154
velocities, standard .....	xxv (06)	154
Turbines, Pelton, cost-speed, characteristic.....	xxv (06)	158
steam, advantages .....	xxi (03)	446
for driving power plant		
auxiliaries .....	xxix (10)	344
cost, estimated .....	xxvii (08)	1131
standby service plant.....	xxix (10)	679
Curtis, space requirements.....	xxi (03)	413
specific consumption .....	xxi (03)	413
DeLaval, description .....	xviii (01)	90
performance .....	xviii (01)	91
double-deck plant .....	xxvii (08)	1099
double-flow horizontal, floor space.....	xxvii (08)	1102
economical load range.....	xxv (06)	46
efficiency tests, different sizes.....	xxix (10)	1697
fixed charges .....	xxvii (08)	1131
force-speed diagrams .....	xxvi (07)	21
governor, functions .....	xxvi (07)	5
Hartford Electric Light Co. installation.....	xxi (03)	450
high vs. low pressure.....	xxix (10)	232
horizontal, floor space.....	xxvii (08)	1102
load-steam curve for 5,000 kw. unit.....	xxv (06)	19

Turbines, steam, ( <i>continued</i> )		
low-pressure, advantages .....	xxix (10)	188
cost .....	xxv (06)	36
economy, estimated.....	xxix (10)	236
effect of nozzle pressure		
on efficiency .....	xxix (10)	243
in steel mills, advantages.....	xxviii (09)	926
minimum economical size.....	xxix (10)	245
performance, tests.....	xxvi (07)	1776
xxix (10)		190
Rateau, steam consumption at different loads.....	xxvi (07)	1753
Rateau type, description.....	xxvi (07)	1745
saving due to use in		
exhaust .....	xxix (10)	244
steam consumption with		
different vacua.....	xxvi (07)	1758
test results .....	xxvi (07)	1739
testing layout.....	xxix (10)	221
use in coal mines.....	xxvii (08)	1582
vs. high pressure.....	xxix (10)	232
operating charges .....	xxvii (08)	1131
Parsons, performance .....	xviii (01)	92
performance (750 kw.), tests.....	xxv (06)	54
tests .....	xxi (03)	463
plants (see Power plants).		
economy, effect of load-factor.....	xxv (06)	59
power capacity, ratio to boiler power		
capacity .....	xxvii (08)	1107
regulation, force-speed diagrams.....	xxvi (07)	21
single-flow horizontal, floor space.....	xxvii (08)	1102
specific consumption, effect of change		
in superheat .....	xxv (06)	19
specific consumption-load characteristics.....	xxv (06)	53
standby charges .....	xxix (10)	681
service, general specification.....	xxix (10)	678
operation cost.....	xxix (10)	683
superheat, effect on economy.....	xxi (03)	464
testing, condenser as calorimeter.....	xxix (10)	1701
methods .....	xxix (10)	1679
pressure correction factor.....	xxix (10)	1701
superheat correction factor.....	xxix (10)	1701
vacuum, precision measurement.....	xxix (10)	1706
weighing tanks, construction.....	xxix (10)	1701
time to start .....	xxix (10)	680
vacuum, effect on economy.....	xxi (03)	464
valve gear, functions.....	xxvi (07)	4
Westinghouse-Parsons, space requirements .....	xxi (03)	413
Yale & Towne installation, description.....	xxi (03)	446
water, compensated governor.....	xxv (06)	171
Electrical Development Co., description.....	xxiv (05)	815
horizontal, space compared with vertical.....	xxiv (05)	816
Pelton, efficiency, test.....	xxii (03)	630, 632
speed control .....	xxv (06)	165
regulation in parallel-operated		
plants .....	xxix (10)	570



- Turbines, water, (*continued*)  
     vertical, space compared with horizontal.xxiv (05) 816
- Turbo-generators (see Generators).
- Ultra-violet rays, treatment of disease.....xxi (03) 393
- Unbalanced circuits (see Circuits).
- Unipolar generators (see Generators, acyclic).
- United Electric Light & Power Co., description of distribution system .....xxviii (09) 805
- United States Naval Academy, date of founding.....xxvi (07) 1432
- Units, c. g. s., electromagnetic, suggested names.....xxii (03) 534  
     electrostatic, suggested names.....xxii (03) 535, 537, 538  
     resistance relation to ohm.....xxii (03) 531  
     rational system, definition .....xxii (03) 529
- University of Illinois, electric test car, description.....xxv (06) 507  
     Michigan, method of teaching engineering..xxvi (07) 1462
- Vacuum, precision measurement .....xxix (10) 1706
- Valtellina line, overhead construction.....xxiii (04) 91  
     locomotive dimensions compared with New York Central d. c. machine.....xxiv (05) 501  
     efficiency .....xxiv (05) 503, 523  
     frictional resistance .....xxiv (05) 503  
     life of bearings.....xxiv (05) 474
- Railway, cost of train operation.....xxiv (05) 501  
     description .....xix (02) 515  
     overhead construction .....xxiv (05) 100  
     performance tests .....xxiv (05) 494  
     recorded load curve.....xxiv (05) 493
- Valve gear, engine, functions.....xxvi (07) 4
- Vapors, luminescence, maximum efficiency.....xxv (06) 798  
     theory .....xxv (06) 796  
     product, definition .....xxvii (08) 891
- salt, electric conduction .....xxv (06) 737
- Vectors, alternating quantities, classification.....xxix (10) 1234  
     diagrams, alternating quantities.....xxix (10) 1254  
     clockwise, development .....xxix (10) 1268  
     power .....xxix (03) 596  
     three-phase system .....xxvii (08) 804  
     various apparatus (see name of apparatus).
- methods vs. topographical .....xxi (03) 594
- power, point-analysis representation.....xxix (10) 1275
- representation of complex current.....xxv (06) 685  
     power .....xxi (03) 596
- rotating, application, harmonic quantities.....xxix (10) 1235
- rotation, clockwise, books in which used.....xxix (10) 1247  
     development .....xxix (10) 1268  
     counter-clockwise, books in which used.xxix (10) 1248  
     objections .....xxix (10) 1271  
     motion for standardization of direction.xxix (10) 1272
- stationary, diagrams .....xxix (10) 1254  
     rotative qualities .....xxix (10) 1259
- Ventilation (also see Heating).  
     generators, Niagara No. 1.....xviii (01) 476  
     spaces (see Cooling).  
     storage battery room .....xxviii (09) 852
- Visual usefulness, criterion .....xix (02) 9
- Volt, legal value .....xxii (03) 521

- Voltage, critical (see Corona).  
 transformers (see Transformers, shunt).  
 unbalance, effect on heating induction motors...xxviii (09) 582  
     induction motor perform-  
     ance, tests .....xxviii (09) 559  
     open-delta transformers...xxviii (09) 573  
     power of induction motors.....xxviii (09)  
     562, 576  
     power of synchronous  
     motors .....xxviii (09) 570
- Voltmeter, Armstrong recording .....xxii (03) 689  
 corona, calibration curves .....xxiii (04) 132  
     description .....xxviii (09) 801  
     use .....xxiii (04) 132  
 electrostatic, advantages .....xxiv (05) 437  
     errors .....xxiv (05) 445  
     Westinghouse, calibration curve...xxiv (05) 443  
     description .....xxiv (05) 438  
     dimensions .....xxiv (05) 442  
     weight .....xxiv (05) 443  
 inductance measurements .....xxv (06) 720  
 iron-loss .....xxviii (09) 424, 427  
 limitations for high-tension measurements...xxiv (05) 424  
 repulsion, construction .....xxiii (04) 137
- Volunteer Electrical Corps, account of work in Boston  
 Harbor .....xix (02) 727
- Vreeland electrolytic wave detector (see Polariphone).
- Wall bushings, condenser type.....xxviii (09) 209
- Warships, first electrically lighted.....xix (02) 579
- Ward Leonard single-phase railway system (also see  
 Railways) .....xx (02) 155  
 single-phase railway system, advantages...xix (02) 1013
- Washington, Baltimore & Annapolis single-phase railway,  
 description .....xx (02) 15  
     single-phase railway,  
     generating equip-  
     ment .....xx (02) 27  
 state, estimated water-power.....xxvii (08) 380
- Water, conductivity, thermal .....xxiv (05) 403  
 friction coefficient with concrete.....xxv (06) 154  
 rheostat (see Rheostat).  
 sand carrying capacity, relation to velocity.....xxv (06) 153  
 wheels (see Turbines).
- Water-hammer in penstocks, prevention.....xxvi (07) 183  
 prevention.....xxii (03) 631; xxiv (05) 815
- Water-power, aggregate in U. S. ....xxix (10) 1037  
 available in U. S. ....xxviii (09) 170  
 classification .....xxv (06) 181  
 conservation charge, suggested system...xxvii (08) 483  
     discussion .....xxix (10) 1037  
     policy of Forest Service...xxvii (08) 486, 490  
 demand of different industries in U. S....xxvii (08) 384  
 development, chief requirements.....xxvii (08) 819  
     cost estimate, outline.....xxvii (09) 1434  
     in New England.....xxviii (09) 1406  
     in southeastern states...xxviii (09) 1453  
     for irrigation project.....xxviii (09) 1471

Water-power, development, (*continued*)

in National forests, sug-		
gested policy .....	XXVII (08)	475
on public domains.....	XXVIII (09)	1465
outline .....	XXVI (07)	179
preliminary data required.....	XXV (06)	183
relation to conservation.....	XXVIII (09)	1362
unfavorable features.....	XXVIII (09)	1364
enterprises, capitalization .....	XXVIII (09)	1412
estimated, Mississippi river.....	XXVII (08)	380
Niagara Falls .....	XXVII (08)	379
Southern Appalachian system.....	XXVII (08)	380
California .....	XXVII (08)	380
State of Washington.....	XXVII (08)	380
United States .....	XXVII (08)	380
government control .....	XXVIII (09)	1435, 1467
operation with induction generators.....	XXVII (08)	240
rainfall (see Rainfall).		
relation of water velocity to sand-carrying		
capacity .....	XXV (06)	153
to electrochemical processes.....	XXVIII (09)	1363
irrigation .....	XXVIII (09)	1363
run-off, effect of forests.....	XXIX (10)	1040
secondary cost of development.....	XXVII (08)	838
securities, value .....	XXVIII (09)	1361
storage of electric energy as heat.....	XXVII (08)	1600
stream flow, effect of forests.....	XXIX (10)	1038
measurement .....	XXVIII (09)	1429
relation to power developed.....	XXV (06)	148
tax, injustice .....	XXVIII (09)	174
taxation, objections .....	XXIX (10)	1043
tunnels (see Tunnels).		
Watering stock, justification .....	XXVIII (09)	1464
Waterways, inland vs. railways.....	XXVIII (09)	176
Watt-hour meter (see Meter).		
Wattmeter, Armstrong recording .....	XXII (03)	689
electrostatic, principles .....	XIX (02)	1036
high-tension .....	XXVII (08)	848
measurements, errors due to series trans-		
formers .....	XXIV (05)	168
errors due to shunt trans-		
formers .....	XXIV (05)	167
Weston, performance as power-factor meter.....	XVIII (01)	303
Wave detectors, audion, acoustical theory.....	XXV (06)	770
life .....	XXV (06)	762
theory of operation.....	XXV (06)	755
electrolytic characteristics .....	XXV (06)	772
Fessenden hot-wire barretter, charac-		
teristics .....	XXV (06)	784
liquid barretter, character-		
istics .....	XXV (06)	785
polariphone, characteristics .....	XXV (06)	772
vacuum tube, hot-electrode.....	XXV (06)	755
distortion, effect on core losses in transformers.....	XXVI (07)	1182
exciting current in trans-		
formers .....	XXVI (07)	1182

- Wave (*continued*)
- electric, analogy with water waves.....XXVI (07) 502
  - atmospheric absorption, effect of wave
    - length .....XXVII (08) 611
    - tests .....XXVII (08) 608
  - effect on electric conduction of arcs.....XXV (06) 740
    - flames.....XXV (06) 738
    - in vacuum.....XXV (06) 741
  - generator apparatus .....XXVII (08) 582
  - half, production for test purposes.....XXVI (07) 1080
  - popular discussion .....XIX (02) 109
  - measurement, bibliography .....XXIV (05) 213
  - motion, Heaviside's explanation .....XXVII (08) 1312
  - pressure in water, calculation .....XXV (06) 168
  - sine, production by inductance and capacity.....XXII (03) 541
  - sound, propagation .....XIX (02) 570
  - standing, definition.....XXVI (07) 414; XXVII (08) 1232
    - equation .....XXVI (07) 415
  - tracer, cathode tube, circuit diagram.....XXII (03) 542
    - construction .....XXII (03) 540
  - transmission line, mechanical model.....XIX (02) 261
  - traveling, attenuation constant.....XXVII (08) 1263
    - general equation .....XXVII (08) 1260
    - transmission line, causes .....XXVI (07) 411
  - Wave-form analysis, Thompson method.....XXIX (10) 883
    - distortion, causes in iron loss tests.....XXVIII (09) 442
    - early Niagara generators.....XXVIII (01) 474
    - effect of resistance in series with transformer.XXV (06) 713
      - transformer connections.....XXV (06) 700
      - iron losses.....XXVIII (09) 418;
        - XXIX (10) 892
      - regulation .....XXVIII (01) 360
    - e. m. f., effect of series resistance.....XXII (03) 368
    - harmonics (also See harmonics).
      - artificial, sources in cable system.XXVIII (09) 835
      - even, production .....XXVIII (09) 727, 733
    - measurement methods .....XXIV (05) 185
    - relation to corona .....XXVIII (09) 775
    - sine shape from any circuit, method.....XXVIII (09) 435
    - transformer currents and e. m. f. experimental
      - investigation .....XXIX (10) 809
  - Weather-proof insulation, life out-of-doors.....XXII (03) 761
  - Weber photometer (see Photometer).
  - Wehnelt interrupter, mode of operation .....XIX (02) 293
  - Westinghouse World's Fair transmission exhibit 1893,
    - description .....XXVIII (01) 455
  - Westminster church, Kansas City, lighting specifications..XXV (06) 646
  - Weston cell, (see Cell).
    - instrument, characteristics .....XXIV (05) 232
    - wattmeter (see Wattmeter).
  - West Penn Railway system, map .....XXIV (05) 956
  - West Point, double-deck turbine plant .....XXVII (08) 1103
    - station, cost .....XXVII (08) 1119
  - Westover carbon-dioxide recorder .....XXVI (07) 1777
  - West Jersey and Seashore R. R. signal system.....XXVI (07) 1546
  - West Side Elevated Railway, Chicago, cost of operation...XXVI (07) 141

Wheatstone printing telegraph (see Telegraph printing).		
Wheels, driving, slipping point, change due to internal		
action .....	XXIV (05)	593
friction, wet, dry and sanded rail .....	XX (02)	244
iron, friction coefficient .....	XX (02)	245
radius of gyration .....	XX (02)	166, 260
steel, friction coefficient .....	XX (02)	245
Whistle, solenoid, used on war ships .....	XIX (02)	613
Whitney mine hoists, load diagram, calculation.....	XXIX (10)	298
Willan's water line .....	XXV (06)	53
Wilson, mutual inductance neutralizing device for		
telegraphs .....	XXIX (10)	1325
Wind pressure .....	XXIII (04)	515
calculations, factor-of-safety .....	XXVII (08)	934
on cables .....	XXVII (08)	935
transmission towers .....	XXVII (08)	932
velocity, maximum .....	XXIII (04) 515; XXIII (04)	527
Windage loss, Ilgner hoisting system .....	XXIX (10)	335
Windings, armature a. c. mechanical construction.....	XXIII (04)	270
chorded, copper utilization .....	XXVII (08)	1079
effect on armature reaction.....	XXVII (08)	1080
wave form .....	XXVII (08)	1082
space utilization .....	XXVII (08)	1078
field, construction Niagara generator No. 1.....	XVIII (01)	467
fractional pitch for induction motors, design.....	XXVI (07)	1485
induction motor differential factor, definition.....	XXVI (07)	1486
fractional pitch, effect on		
excitation .....	XXVI (07)	1525
insulation, (see Insulation).		
Winnipeg river span, data on construction .....	XXVII (08)	457
Winona Copper Co., hoisting plant, description.....	XXIX (10)	327
Wireless industry, government interference, examples.....	XXVII (08)	614
Marconi system, evolution from wire telegraph.....	XIX (02)	112
popular explanation .....	XIX (02)	112
signalling, brief history .....	XXVII (08)	553
Wireless telegraph (see Telegraph).		
Wires aluminium, expansion coefficient .....	XXIII (04)	514
experiments on 1,000-ft. span.....	XXIII (04)	527
modulus of elasticity .....	XXIII (04)	514
tensile strength .....	XXIII (04)	514
armor, tensile strength .....	XIX (02)	694
convection loss, forced ventilation, tests.....	XXVIII (09)	378
loss in free air, tests .....	XXVIII (09)	365
copper, annealing, effect of temperature.....	XXII (03)	699
expansion coefficient .....	XXIII (04)	514
conductivity relation to tensile strength.....	XXII (03)	698
hard, elastic limit .....	XXIX (10)	989
expansion, temperature coefficient.....	XIX (10)	989
modulus of elasticity .....	XXIX (10)	989
resistance .....	XXIX (10)	989
tensile strength .....	XXIX (10)	989
weight .....	XXIX (10)	989
modulus of elasticity .....	XXIII (04)	514
tensile strength .....	XXIII (04)	514
relation to electric con-		
ductivity .....	XXII (03)	698

Wires (*continued*)

copper-clad	elastic limit	XXIX (10)	989
	expansion temperature coefficient	XXIX (10)	989
	modulus of elasticity	XXIX (10)	989
	resistance	XXIX (10)	989
	tensile strength	XXIX (10)	989
	weight	XXIX (10)	989
	current-carrying capacity (see Current carrying capacity).		
galvanized,	corrosion by high-tension field	XXI (03)	290
	tests for quality	XIX (02)	695
ground (see Ground wire).			
gutta percha breakdown e. m. f. for different			
thickness		XXIV (05)	413
heating (see Current-carrying capacity) (see Heating).			
high-tension, electrical properties		XIX (02)	218
	puncture tests	XXV (06)	200
insulation (see Insulation).			
iron expansion coefficient		XXIII (04)	514
galvanized, elastic limit		XXIII (04)	514
	modulus of elasticity	XXIII (04)	514
	resistance to alternating current	XXVI (07)	567
	tensile strength	XXIII (04)	514
phono-electric	elastic limit	XXIX (10)	989
	modulus of elasticity	XXIX (10)	989
	resistance	XXIX (10)	989
	expansion temperature coefficient	XXIX (10)	989
	tensile strength	XXIX (10)	989
	weight	XXIX (10)	989
radiation losses		XXVIII (09)	370
reactance table for different sizes and spacings		XXIV (05)	401
resistance, thermal, in molding		XXVI (07)	984
rubber-covered, capacity measurement		XXVI (07)	999
	characteristics	XXV (06)	195
	dielectric loss (see Insulation).		
	conductance measurement	XXVI (07)	999
	dielectric loss, different types, tests	XXVI (07)	1005
	effect of chemical composition on		
	properties of rubber	XXVI (07)	1013
	insulation resistance as index of		
	quality of insulation	XXV (06)	204
	resistance of different		
	types, tests	XXVI (07)	1005
	resistance, tests	XXV (06)	200
	power-factor of different types,		
	tests	XXVI (07)	1005
	puncture, tests	XXV (06)	200
	choice of potential	XXV (06)	203
	resistance measurement	XXVI (07)	999
	specifications for 30% compound	XXV (06)	211
	specific capacity of different types,		
	tests	XXVI (07)	1005
steel, effect of locomotive blast		XXVII (08)	1705
	elastic limit	XXIX (10)	989
	expansion coefficient	XXIII (04) 514; XXIX (10)	989
	modulus of elasticity	XXIII (04) 514; XXIX (10)	989
	resistance	XXIX (10)	989

Wires, steel, ( <i>continued</i> )		
tensile strength .....	XXIX (10)	989
weight .....	XXIX (10)	989
stranded (see Cables).		
telephone, rubber-covered, life .....	XXVI (07)	585
trolley, splices .....	XXIX (10)	1005
Wollaston, properties .....	XXV (06)	784
Wiring, central stations .....	XXIV (05)	32
diagram, Manhattan Railway power plant.....	XXIII (04)	200
parallel operation of transmission lines.....	XXIII (04)	547
synchronous converter, railway substation.....	XXII (03)	270
three-phase four-wire generators, single-		
phase system .....	XVIII (01)	808
generator, four-wire three-		
phase system.....	XVIII (01)	810
three-wire single-		
phase system.....	XVIII (01)	809
Ward-Leonard control, coal hoist.....	XX (02)	141
factory lighting .....	XXIX (10)	170
generators .....	XXIV (05)	32
gold dredge .....	XXII (03)	516
high-tension, converter substation .....	XXVI (07)	860
outdoor layout .....	XXVIII (09)	259
rules .....	XXVI (07)	857, 865
stations .....	XXVI (07)	1334
enclosed vs. open bus system.....	XX (07)	
general discussion.....	XXVI (07)	851
power plants .....	XXV (06)	581
Fisk Street Station, Chicago, high-		
tension diagram .....	XXIII (04)	240
Harrison Street Station, Chicago,		
high-tension diagram .....	XXIII (04)	239
main and group buses, diagram.....	XXIII (04)	213
rules, U. S. Navy .....	XIX (02)	603
station, electrical properties .....	XIX (02)	219
feeders, direct connection to bus, reasons.....	XXIII (04)	206
generators direct connection to bus,		
reasons .....	XXIII (04)	206
substation .....	XXI (03)	429
switchboard, central station .....	XXIV (05)	34
transformer station, Buffalo terminal house.....	XVIII (01)	837
Wisconsin Steel Co., low-pressure turbine plant,		
description .....	XXVI (07)	1740
Wollaston wire, properties .....	XXV (06)	784
Woolen mills (see Textile mills).		
Workers professional, number in U. S. ....	XXIX (10)	650
skilled, number in U. S. ....	XXIX (10)	650
Wright printing telegraph (see Telegraph printing).		
Yadkin river, drainage river .....	XXIV (05)	795
rainfall .....	XXIV (05)	796
run-off .....	XXIV (05)	796
Yale and Towne turbo-generator installation, description.....	XXI (03)	446